United States
Department of
Agriculture

Forest Service

Rocky Mountain
Forest and Range
Experiment Station

Fort Collins
Colorado 80526

General Technical
Report RM-GTR-260

Distribution of Abandoned and Inactive Mines on National Forest System Lands

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Abstract

Shields, Deborah J.; Brown, Douglas D.; Brown, Thomas C. 1995. Distribution of abandoned and inactive mines on National Forest System lands. Gen. Tech. Rep. RM-GTR-260. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 195 p.

This report characterizes the distribution of abandoned and inactive mines throughout the United States. The assessment is based on the nonconfidential portion of the Minerals Availability System (MAS) database compiled by the U.S. Department of Interior, Bureau of Mines. The data provide a reasonable estimate of the minimum number and types of mines on or near National Forest System lands.

Keywords: abandoned mines, inactive mines, reclamation, mineral locations, National Forest System, RPA

USDA Forest Service
General Technical Report RM-GTR-260

April 1995

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Introduction

Mining in the United States has a rich and colorful history. Domestic mineral production has facilitated economic growth, while furnishing many interesting tales of courage, hardship, and wealth creation. However, the industry has left another, less desirable legacy - abandoned mines. Before the 1970s, reclamation of mine sites was not required, and consequently, was not performed for most sites. Abandoned mines often were simply ignored. Although they may be of historical interest, abandoned mines are creating current problems. Unreclaimed sites often detract esthetically from the landscape and pose physical hazards that could cause personal injury. Moreover, both surface and underground mines, as well as mill tailing and smelter waste dumps, can discharge toxic materials and sediments that degrade water quality.

Currently, responsibility for cleaning up abandoned mine sites, depending on the locatability and financial viability of the private parties who operated the site, may be shared among federal and state agencies and the private entities involved. Typically private land owners are responsible for safeguarding hazards on their property. Similarly, the private mine owner or operator is responsible for safeguarding the public from hazards at active and inactive mine sites, but at the direction of the land management agency. Abandoned sites can be a problem, especially if the non-federal owner or operatr cannot be located, or is

tion); and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), which establishes the Forest Service's authority to clean up and restore natural resources at sites and seek cost recovery from potentially responsible parties. The state laws depend on programs the respective state is administering under its own authorities, or under EPA oversight.

Heightened concern about the negative impacts of abandoned mines on environmental quality are leading federal land management agencies to clean up mine sites left by others, and over which they historically had no enforceable authority. Although the Forest Service now has one of the more active CERCLA clean up programs in the Nation, it is spending puclic money to clean up privately caused pollution at these mine sites.

A significant portion of the Nation's mining has occurred on or near National Forest System (NFS) lands. This report characterizes the distribution of inactive and abandoned mines throughout the United States. The goal of the report is to provide a general understanding of the extent to which abandoned mines are likely to be found throughout the thousands of acres of NFS lands. Although we do not present great detail about individual national forests (NFs), this report indicates where among the Nation's NFS lands concerns regarding abandoned mines are the greatest.

This assessment is based on the nonconfidential portions of the Mineral Availability System (Mineral

MT) or misleading (e.g., ND). Further, the USBM definition of a mineral location differs from that used by some state agencies, leading to differing estimates of the magnitude of the problem. Readers are cautioned to utilize this study, and the data reported herein, only in a general manner. Nevertheless, we believe that the data provide a reasonable basis for characterizing a **lower limit** on the number of abandoned and inactive mines on and near national forests throughout the United States.

Design and Structure of the Minerals Availability System/Mineral Industry Location System Database

The Minerals Availability System/Mineral Industry Location System (MAS/MILS) database was established to provide comprehensive information for known mining operations, mineral deposits/occurrences, and processing plants. The non-proprietary information of the database is available to the general public and is referred to as the MAS Non-Proprietary (MAS/MILS) database. As the USBM points out, MAS/MILS is a working file. Data accuracy varies from preliminary, unconfirmed reports to validated assessments (USDI–Bureau of Mines 1993).

tance of the minerals industry in that State. Conversely, minimal data on Nebraska and Kansas are included, because their non-energy minerals industries were designated too limited to warrant expenditure of scarce data collection funds. The USBM data collection project was undertaken after responsibility for energy minerals had been shifted from that agency to the Department of Energy. As a result, oil and natural gas coverage is virtually nonexistent. Coal and uranium location data are fairly complete for a few states, such as North Dakota; but quite limited for most others. This partial treatment can be misleading. For example, the inclusion of 939 past producing coal mines in the North Dakota files gives that State undeserved prominence as an historic mining region. Also, information on minerals operations may be incomplete, because some state data included records for all past producers, while others did not (Fantel 1993). This is particularly a problem in the case of Montana, which has a long history of mining, but for which there are relatively few entries in MAS/MILS. As a result, use caution when comparing gross mineral activity levels across states.

Other complications result from different definitions being used by different agencies. The USBM defines as one mineral location[5] all of the facilities ously, the USBM data represent a lower limit on the number of abandoned mines in the United States.

The MAS/MILS database is comprised of several data tables. This report focuses on two of them: the Mineral Industry Location System (MILS) table, and the commodity table. Tables are related to each other by a unique, 10-digit sequence number. The sequence number consists of a three-digit state Federal Information Processing Standards (FIPS) code (USDC, National Bureau of Standards 1987), a three-digit county FIPS code, and an arbitrary four-digit site reference number. Each sequence number refers to a unique mining operation, mineral deposit, or processing plant.

The MILS table consists of locational and descriptive information for each mine. Examples of descriptive information include type of operation and current status. Locational and descriptive data are arranged in a one-to-one relationship for each deposit.

The commodity table focuses on commodities that are or can be recovered from a mineral deposit, as well as commodities that may adversely affect the recovery of other commodities from that deposit. "Commodities" that may affect recovery of other commodities include water and sulfur. Commodity data are arranged in a one-to-many relationship, because one deposit may yield more than one commodity. Currently, there are 207,242 and 285,949 records in the MILS and commodity tables, respectively. The difference in the number of records results from the potential for more than one commodity at each deposit. Direct comparisons should not be made between totals or subtotals produced from the MILS and commodity data. Although information on mineralogy of ore bodies would be useful for water quality studies, these data are not always reported in MAS/MILS.

The terms "cannot verify" and "unknown" are valid entries to certain fields in the data tables. In addition, some or all of the fields for a particular deposit may have been left blank, in which case the observations were aggregated and reported separately in this publication.

Distribution of Mineral Locations

The MAS/MILS database for the United States comprises 207,242 domestic mineral locations, as of 1992. As figure 1 illustrates, their geographic distribution is uneven. Some areas of the country have experienced a great deal of mining activity, others relatively little. Readers familiar with the industry will be able to identify numerous historic mining districts, such as the Minnesota iron range, the California placer district, and the Arizona copper belt, by the intensity of activity in those areas. However, the high levels of mining activity in states such as Iowa, where coal mining was common, may be somewhat unexpected. States with significant past or current mining activity, as reported in MAS/MILS, are listed in table 1.

Table 1.—States with significant mineral activity.[1, 2]

	Past producers	Total mineral locations
Alaska	2,230	7,263
Arizona	3,592	10,512
California	7,002	28,194
Colorado	8,837	13,865
Idaho	2,356	8,837
Iowa	3,984	4,851
Missouri	13,614	14,699
Nevada	3,711	8,504
Oklahoma	4,086	4,807
Utah	3,337	6,621
Washington	2,659	10,948
Wisconsin	3,011	5,745
Wyoming	1,567	5,269

[1]*Coal and uranium underrepresented in data.*

[2]*Montana has had significant mineral activity, but this fact is not reflected in the MAS/MILS data base. Complete reporting would place Montana close to Colorado in number of past producing operations.*

Type and Status

MAS/MILS includes selected information for each mineral location, of which Type and Status are particularly important. Type refers to the past, current, or expected future activity at a location (table 2). Extraction sites have been assigned to one of nine mining types. Beneficiation plants not associated with a specific mine were included in the category Processing Plants, which is generally applied to smelters, refineries, etc. Undeveloped properties either were assigned to the expected mining method, or, in other cases, to Mineral Location or Prospect. Where little information was available, Type was listed as Unknown. This designation usually is associated with mineral locations identified from the literature. Frequency of Type by State is reported in Appendix A.

Almost half of the mineral locations in MAS/MILS are designated as surface mines (fig. 2), reflecting, in part, the large number of sand, gravel and stone operations in the country. Underground and combined surface-underground operations, which account for another 27% of the sites, are more typical of metallic ore mining. Approximately 4% of the locations are, were or are expected to be placer mines.

Each mineral location has been assigned a Status by the USBM (table 3) identifying the stage of mine development achieved at the site. Mineral development activities tend to take place in a consistent order. The purpose of the initial activities is to gain information about the character, grade, and extent of subsurface resources sufficient to determine if an economic deposit is present. Whether each succeeding step is undertaken depends upon the information gained from the previous step. In general, the actions become more expensive, and more physically disruptive to the site, at each successive stage. If initial prospecting (e.g., geochemical, geophysical, seismic) indicates that the site might contain mineral resources, then exploration (e.g., core drilling) begins. This stage is followed by more extensive exploration (e.g., an exploration shaft), if presence of a deposit is suspected. For economic deposits, the normal course of events would be permitting (by state and local authorities), operating plan review (by federal land managing agency), site development (surface and underground facility construction), production, and eventually shut down. Current Forest Service regulations require reclamation; however, a "past producer" designation in the data base does not necessarily mean that reclamation has taken place.

Table 2.—Frequency of type — all sites.

Type	Frequency	Percent	Cumulative frequency	Cumulative percent
Brine	23	0.0	23	0.0
Hot spring	135	0.1	158	0.1
Leach	52	0.0	210	0.1
Mineral location	12,874	6.2	13,084	6.3
Placer	8,772	4.2	21,856	10.5
Processing plant	3,789	1.8	25,645	12.4
Prospect	20,711	10.0	46,356	22.4
Surface-underground	8,850	4.3	55,206	26.6
Surface	92,951	44.9	148,157	71.5
Underground	46,696	22.5	194,853	94.0
Underwater	477	0.2	195,330	94.3
Unknown	10,569	5.1	205,899	99.4
Well	1,343	0.6	207,242	100.0

Table 3.—Frequency of status — all sites.

Type	Frequency	Percent	Cumulative frequency	Cumulative percent
Cannot verify	17	0.0	17	0.0
Developed deposit	5,192	2.5	5,209	2.5
Explored prospect	24,834	12.0	30,043	14.5
Other	667	0.3	30,710	14.8
Past producer	89,081	43.0	119,791	57.8

The USBM ranks sites at which mining has not yet taken place in the following manner. Preproducers for which little exploration has been completed are ranked as Raw Prospects. Increasing amounts of exploration lead to the category of Explored Prospect. A Developed Deposit is a partially or wholly constructed mine at which production has not yet commenced. There is a fine distinction between Explored Prospect and Developed Deposit, in that exploration activities continue during development and certain development activities (e.g., roads, pilot plant construction) occur early in the exploration phase. As a result, coding is to some extent dependent upon the judgement of the coder.

The categories of Producer, Temporary Shutdown, and Past Producer are self explanatory. Where minimal information was available, the USBM designation was Unknown. Cannot Verify refers to questionable records. When grouped together, undeveloped deposits account for 43% of entries in MAS/MILS, producing deposits 14% and past producers 43% (fig. 3). Frequency of Status by State is reported in Appendix B.

Because of budget limitations, the USBM regularly updates records for only a subset of the 207,242 mineral locations. As a result, for many properties, information in the Status field may not be current waste materials or exploitation of remaining in-ground resources profitable, thus turning Past Producers back into Producers.

Type and Status are combined in table 4. The original 13 Type designations have been reduced to 4 basic categories: surface, underground and surface/underground, placer, and all others. Similarly, the 9 Status designations have been aggregated into 4: all stages of undeveloped, current producers, past producers, and all those for which status is unknown. (A table with all 13 Type and 9 Status categories is available in Appendix C). Each cell in the table represents the intersection of a Type and a Status, with descriptive statistics provided in each case. Instructions for reading the tables are provided in the beginning of the appendices.

As seen in table 4, 53% of the 89,720 past producers were surface mines, another 37% were underground or combined operations, and 4% were placer mines. Among current producers there is a much greater preponderance of surface operations (77%), and there are fewer placer mines. These changes reflect a shift toward solution mining techniques and away from more expensive or perhaps more environmentally damaging mining methods of the past.

Table 4.—Frequency of type by status.[1]

Type Frequency Percent Row % Col %	Status Past producer	Producer	Undeveloped	Unknown	Total
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.78	0.05	1.10	1.31	4.23
	41.94	1.24	25.90	30.92	
	4.10	0.37	5.01	6.31	
Surface	47,285	22,521	9,758	13,387	92,951
	22.82	10.87	4.71	6.46	44.85
	50.87	24.23	10.50	14.40	
	52.70	77.28	21.50	31.13	
Underground-Surface	33,159	3,157	11,232	7,998	55,546
	16.00	1.52	5.42	3.86	26.80
	59.70	5.68	20.22	14.40	
	36.96	10.83	24.75	18.60	
All others	5,597	3,356	22,117	18,903	49,973
	2.70	1.62	10.67	9.12	24.11
	11.20	6.72	44.26	37.83	
	6.24	11.52	48.74	43.96	
Total	89,720	29,143	45,379	43,000	207,242
	43.29	14.06	21.90	20.75	100.00

[1] *Table 4 and other tables of this type are read as follows: Starting in the lower right hand corner, the upper number (207,242) is the Total number of entries in the table, the lower number (100) is the percent of that Total. The pairs of numbers to the right of the row identifier "total" are the occurrences overall in each column category (here Status) and the percent of Total each represents. The upper numbers add to the Total; the percents add to 100. The pairs of numbers below the column identifier "total" are the occurrences overall in each row category (here Type) and the percent of Total each represents. These add in the same manner: upper to 207,242, lower to 100.*

Each cell contains 4 data items, in order Frequency, Percent, Row %, and Col %. Frequency is the number of occurrences for that row-column pair. Percent signifies the percent of Total that Frequency represents. These can be added either vertically or horizontally to obtain the overall column or row percent values. Row % is the percent of the row total that each cell represents. These values can be compared across the row and add to 100. Col % is the percent of the column total that each cell represents. These should be read and add to 100 vertically.

Domain

Another perspective on the data can be gained by examining mineral location ownership and government administrative patterns. Two alternative approaches are utilized here: USBM "Domain" designations and physical (latitude-longitude) location. The USBM database identifies 23 possible Domain categories, including Private, NFS and numerous other federal, state and local governmental entities, and Unknown. Complete tables of these data, sorted by Type and by Status, are reported in Appendices D and E. Based on this classification system, there are 27,216 mineral locations on NFS lands. The only USBM Domain designations with higher levels of mineral activity are Unknown with 38,621 sites, and Private with 86,778 sites. Despite historically high levels of exploration and mining on lands under BLM administration, the USBM has assigned this Domain only 12,655 sites. The low number may be indicative of relative rates of claim patenting.

USBM Domain numbers are only approximate, as title to land changes hands. As previously noted, the Domain fields represent ownership or administrative responsibility at the time the site was entered into the database. The USBM actively maintains these fields for only a few sites. This is important to keep in mind when reviewing data for minerals on public lands. Mineralized land has been and continues to be transferred to the private sector under the Mining Law of 1872. This law regulates exploration, claim staking, ownership, and production of metallic and some nonmetallic minerals from public domain lands, those which have never left the federal estate.[8] If a U.S. citizen or firm can show that a claim site contains an economically viable deposit, it may be taken to patent, a process by which title to the surface and subsurface is permanently transferred to the private sector. Over the past 122 years, tens of thousands of mineral locations on lands once administered by public agencies have been transferred to private ownership (Leshy 1987).

Many abandoned and inactive mines in the western United States can be found on claims that were taken to patent in the late 1800 and early 1900s. Often these claims lie within what are now the contiguous boundaries of NFS, BLM or other federal lands. Federal employees usually may not enter these privately held sites to ascertain the status of mine workings or evaluate potential physical hazards to individuals or environmental risks to adjacent public lands or waters without permission of the owner.[9] However, the current private owners may be difficult to locate or refuse to allow entry. Many federal agencies (including BLM, NPS, FWS) are in the process of inventorying the abandoned and inactive mines on their lands; however, mine sites on privately owned patented inholdings will not be included in these totals.

Nonetheless, many mines on or within NFS lands have the potential to create environmental problems, including water quality degradation. To provide an estimate of the magnitude of the potential problems active, abandoned and inactive mines pose for the Forest Service and other federal agencies, the data were organized according to location. Administrative boundaries have been digitized for most federal lands (the BLM excepted). Latitude and longitude for each mineral location, as reported in MAS/MILS, were compared to these data. Mineral locations falling within the administrative boundaries of NFS lands were assigned to the NFS administrative category. Mineral locations falling within the administrative boundaries of other federal lands, except BLM, were assigned to Federal Other Than BLM.[10] The remaining sites were assigned to All Other Including BLM. This information has been combined with Type in table 5. Less aggregated tables of the data organized by administrative boundary are available in appendices F and G.

Table 5.—Frequency of type by domain.[1, 2]

Type	Administrative boundaries			
	Domain			
Frequency Percent Row % Col %	NFS[3]	Federal[4]	Other[5]	Total
All others	11,646 5.62 23.30 29.87	2,626 1.27 5.25 38.16	35,701 17.23 71.44 22.12	49,973 14.11
Placer	3,348 1.62 38.17 8.59	352 0.17 4.01 5.12	5,072 2.45 57.82 3.14	8,772 4.23
Surface	8,883 4.29 9.56 22.78	2,281 1.10 2.45 33.15	81,787 39.46 87.99 50.68	92,951 44.85
Underground/Surface	15,114 7.29 27.21 38.76	1,622 0.78 2.92 23.57	38,810 18.73 69.87 24.05	55,546 26.80
Total	38,991 18.81	6,881 3.32	161,370 77.87	207,242 100.00

[1]*Instructions for reading table are located after table 4.*

[2]*Domain determined by comparing latitude and longitude of mineral location, as reported in MAS/MILS,to digitized boundary data.*

[3]*National Forest System lands.*

[4]*All Federal lands other than NFS or BLM.*

[5]*All other lands including private and BLM, which is included here because their boundaries have not been digitized.*

When the data are viewed in this way, approximately 19% of all mineral locations occur within the administrative boundaries of NFS lands, an increase from the 13% occurring on NFS lands according to the USBM designations. Of the total of 38,991 locations, 15,114 are identified as underground or surface/underground mines, 8883 as surface and 3,348 as placer mines (fig. 4). In comparison with the other two Domain categories, a greater proportion of mines within the NFS boundaries tend to be underground and fewer surface. In terms of Status, 13,706 mineral locations within NFS boundaries are past producers,

[8]*Extraction of energy resources and some industrial minerals, as well as mining of all resources on acquired lands, is regulated under the Mineral Leasing Act of 1920 (as Amended.)*

[9]*This does not hold for CERCLA cleanup 104(e). 42 USC 9604 (e).*

[10]*BLM data are not reported separately because BLM boundaries have not been digitized. For this same reason they could not be included in the Other Federal category.*

1,798 are producing, and another 23,487 are as yet undeveloped (or status is unknown) (table 6, fig. 5).

Commodities

The USBM database identifies 89 commodities that may occur singly or in combination at mineral locations. With very few exceptions, these are, or potentially could be, "economic" commodities. A deposit contains an economic commodity if there is a demand for the mineral in the marketplace and its selling price exceeds extraction cost. Pure deposits of most minerals, native silver or copper, for example, are very rare. It is more common for minerals to occur both in combination with each other and with various other elements. The commodities designated for each mineral location by the USBM are those presently or potentially extracted for financial gain. Constituents that could affect marketability often are reported as well. Other elements present, but not of economic significance, including those which at other locations might have been extracted for profit, may not be listed.

This approach to commodity designation has important implications for analysis of the relationship between mines and water quality. Polymetallic ores may have been extracted and processed to retrieve one or several elements considered at the time to be highly valuable. Any other elements of too low a grade (percentage content in the ore) to be economic or for which there was no market at the time, would have ended up in the waste material. As a result, the commodity designated for a site may not be the only mineral present, and the distribution of mines by commodity can only be considered one possible indicator of the presence of environmentally problematic elements.

Table 6.—Frequency of status by domain.[1,2]

Status	Administrative boundaries
	Domain
Frequency Percent	

By far the most common types of mines are those for construction materials; fully 28% of the mineral locations have sand, gravel or stone listed as their primary commodity. The metallic mineral most frequently extracted is, not surprisingly, gold. For arsenic, cadmium, and mercury, the values are indicative only of those sites at which the mineral was designated as the primary commodity. In fact, distribution of the first two is significantly broader than these numbers would suggest, because they are commonly found in polymetallic deposits.

Distribution of Past Producing Mineral Locations

There are approximately 89,081[12] past producing mineral locations in the United States listed in the USBM MAS/MILS database. As figure 7 illustrates, they are found in all parts of the country. Not all abandoned or inactive mines are equally problematic in terms of their potential risk to water quality, however. Many are sand, gravel, or stone operations, as are the string of sites paralleling the TransAlaska Pipeline (fig. 8). The vast majority of mines for these types of commodities have no toxic affects, although they can cause sedimentation problems and be unsightly. For comparison, figure 9 illustrates the distribution of past producers with these three widespread commodities excluded. In following sections, the data are organized by mining method and mineral so as to highlight areas more likely to be at risk for water contamination from past mineral operations.

Past Producers by Type

Surface mining took place at 46,974 past producing mineral locations, underground and combined surface-underground mining at 32,903, and placer mining at 3,674 (fig. 10). By far the most widely distributed type of activity was surface mining (fig. 11). Underground and combined mines tend to be more geographically concentrated, and have been common in the Appalachian, Rocky, and Sierra Nevada Mountains as well as a few central states (fig. 12). Placer mining techniques are less widely applicable, but were commonly utilized during the gold rushes of the 1800s (fig. 13). See also Appendix I for data on the distribution of past producers by State by Type.

[12] This number reflects Past Producers only; the 89,720 reported in table 6 includes temporarily shutdown operations.

Table 7.—Table of domain by type — past producers.[1,2,3]

Type	Administrative boundaries			
Frequency Percent Row % Col %	Domain			
	NFS[4]	Federal[5]	Other[6]	Total
All others	869 0.98 15.71 6.39	333 0.37 6.02 16.10	4,328 4.86 78.26 5.90	5,530 6.21
Placer	1,347 1.51 36.66 9.91	115 0.13 3.13 5.56	2,212 2.48 60.21 3.01	3,674 4.12
Surface	3,689 4.14 7.85 27.13	808 0.91 1.72 39.07	42,477 47.68 90.43 57.86	46,974 52.73
Underground/Surface	7,692 8.63 23.38 56.57	812 0.91 2.47 39.26	24,399 27.39 74.15 33.23	32,903 36.94
Total	13,597 15.26	2,068 2.32	73,416 82.41	89,081 100.00

[1] Instructions for reading are located after table 4.
[2] Domain determined by comparing latitude and longitude of mineral locations, as reported in MAS/MILS,to digitized boundary data.
[3] Past producers here do not include temporarily shutdown operations.
[4] National forest system lands.
[5] All Federal lands except NFS and BLM.
[6] All other lands including BLM and private.

More than 15% of past producing mineral locations, as reported in MAS/MILS, are within the administrative boundaries of NFS lands (table 7 and Appendix I; Appendix J lists Past Producers by USBM Domain). More than 50% of past producing sites within NFS boundaries are underground or combined surface/underground operations. This is consistent with the percentages for mineral activities on NFS overall, but is not unexpected, given that underground mining is common in mountainous areas of the western United States where the agency administers large tracts of land. In addition, a disproportionate 37% of the placer operations took place at locations within what are now NFS boundaries.

The distribution of past producers overall and by mining method within the administrative boundaries of NFS lands are illustrated in figures 14 through 17. It is clear that while forests in all parts of the country are impacted, some areas have seen more historic mining activity than have others.[13]

Past Producers by Commodity

Organizing the data on past producing mines by commodity illustrates several important points. Firstly, one or two mining methods are commonly associated with each commodity. This is not surprising; each mineral is usually found in only a few types of ore bodies (e.g., veins), and the different ore body configurations lend themselves to specific extraction methods. Underground and combined surface/underground mining were the methods of choice at half of the past producers overall, and account for the vast majority of past producing copper, lead, gold, silver, and zinc mines (fig. 18 and Appendix L). Sand, gravel and stone represent half of the past producing surface mines, although this method was also common for lead and iron ore extraction.

The maps of past producing copper, gold, iron, lead, silver and zinc mines illustrate two additional important points (figs. 19- 24). Not all minerals are mined in all places, and some minerals are consistently found in certain areas. To readers familiar with geology this fact is obvious, but it is less widely understood by individuals not associated with the earth sciences. The location of mineral deposits is the result of complex geologic forces occurring over millennia. Some combinations of forces are more likely to lead to deposition of minerals in economic concentrations than are others. Places with the "right" geologic characteristics are logically the areas of interest for mineral extraction and many have experienced heavy mining activity over the years. The following are a few examples of this phenomenon.

There were large copper mines in Michigan and Montana and also in Arizona, where the industry remains important to the economy to this day. Development of the Copper Basin followed discovery of native copper in southeastern Tennessee. Eventually, more than 56 square miles of land were desertified by smelting activity. Gold mining was of enormous importance to the history and settlement of much of the west, particularly Colorado, California, Nevada and western South Dakota. Extraction of this metal continues and the United States is currently the second largest gold producer in the world (USBM 1993). The presence of iron resources (in Minnesota, Michigan and in the East) was a deciding factor in locating the American steel industry along the Great Lakes and in Pennsylvania. Lead mining has been an important industry in Illinois and Wisconsin, and remains so today in Missouri. Silver mining drove the development of many western towns such as Leadville, CO. Zinc mining also has impacted Colorado along with Missouri, Illinois, Idaho, Washington, and Wisconsin. (See appendix M for detailed data on past producers by commodity, by state).[14]

National Forests located in areas that have experienced past mineral activity are more likely to have past producers within their boundaries. Table 8 lists the frequency of occurrence of past producers within NFS boundaries for selected commodities. (Also see appendix N for detail.) Again the preponderance of underground mining operations is clear.

Of the minerals listed in table 8, some are of more concern to water quality than others. Among metals, arsenic,[15] cadmium, copper, lead, mercury, and zinc, have significant potential to cause water quality problems. We have labeled this group as minerals of concern. The level, if any, of environmental problem created by the presence of one of these minerals is a function of acidity, moisture, background geology and a host of other factors. Nonetheless, their presence warrants heightened awareness and oversight.

The USBM has identified 29,380 occurrences of these minerals at past producing mines in the United States (as indicated by their listing as economic commodity for the site). The minerals of concern have been mapped (fig. 25) to highlight the magnitude of the abandoned and inactive mine problem for the Forest Service. Red dots mark sites within NFS administrative boundaries. It should be noted, however, that minerals of a concern (because of toxicity) may be present in uneconomic quantities at other locations.

[13] *Because of the broad scope of this study, the data are not reported by individual National Forest.*

[14] *Inactive and abandoned mine data are also available from the Western Governor's Association (Western Interstate Energy Board 1991; Interstate Mining Compact Commission 1992.)*

[15] *It should be noted that arsenic may be present because it was co-produced or because it was used at a mining operation to facilitate recovery of a commodity (i.e., gold). It is seldom a primary product of mining.*

Table 8.—Past producers on NFS:[1] selected commodities and type of operation.

	Surface	Surface-underground & underground	Placer	Processing plant	Other	Total
Arsenic	1	28	0	0	5	34
Cadmium	0	12	0	0	0	12
Copper	83	2,159	4	10	184	2,440
Gold	268	4,355	1,334	34	348	6,339
Iron	470	320	8	3	50	851
Lead	145	2,800	2	23	146	3,116
Mercury	8	62	5	0	2	77
Silver	120	4,189	548	31	308	5,196
Zinc	76	1,928	1	18	63	2,086
Total	1,171	15,853	1,902	119	1,106	20,151

[1]*Domain determined by comparing latitude and longitude of mineral locations, as reported in MAS/MILS, to digitized boundary data.*

Table 9.—Past producing underground and surface-underground mines[1] with selected minerals[2] of concern.

Commodity	Frequency
Arsenic	73
Cadmium	48
Copper	6,090
Lead	10,113
Mercury	293
Zinc	7,949
Total underground and surface-underground mines at which at least one of the above minerals occur	13,281

[1]*First occurrence only.*

[2]*50% of locations have at least 2 of listed minerals.*

There are 13,281 past producing underground and surface/underground mines at which at least one of these minerals was the primary commodity (table 9). As figure 26 clearly shows, many were located within the boundaries of NFS lands. Distribution of past producing surface operations, at which at least one of the minerals of concern was extracted, is illustrated in figure 27.

Conclusions

This survey has of necessity been very general in its analysis. It has been based on the USDI Bureau of Mines MAS/MILS database, the original purpose of which was not cataloging the locations of past producers. One result is that coverage is incomplete, and care must be taken to avoid mischaracterization of the issue as a result of data shortcomings. This database is, nonetheless, the largest single collection of this type of data available in an automated information system.

Federal land management agencies, and numerous states, are in the process conducting comprehensive inventories of abandoned and inactive mines. Although data needs and project goals differ among the various agencies, efforts are being made to standardize definitions and share information (Juntunen 1993). Until these surveys are completed, the MAS/MILS numbers should be considered as a lower limit estimate of the number of abandoned and inactive mines existing in the United States.

The MAS/MILS database focusses on nonenergy resources; it has very limited coverage of energy resources, incomplete information on background mineralogy, and minimal data on physical features or acreage disturbed. However, other existing data sources may provide information to fill these gaps. The USDI Mine Safety and Health Administration maintains excellent records on active mines, including coal mines. However, these data are not organized by location. The National Inventory of coal mines was started in 1977 by the USDI Office of Surface Mining (OSM). The data are currently in paper format only. Merging OSM and MSHA data with USBM data will be difficult and time consuming.

The USDI Geological Survey maintains the Mineral Resource Data System (MRDS) database, which contains extensive information on geology and mineralogy. Many of the USBM records list only commodities, so additional background information on the mineralogy of an area will be necessary if all potential water contaminants are to be identified. More than 75% of the mineral locations in MRDS are identified by latitude and longitude; more than 20,000 also have the USBM Sequence Number listed. Merging these data with MAS/MILS will be challenging, and care will need to be taken to avoid duplication of records; however, a cooperative effort to accomplish this task is ongoing.[16]

As previously noted, another source of information is the four-volume study on Inactive and Aban-

[16]*Forest Service Research is lead agency on the project and is working in cooperation with the Geological Survey and the Bureau of Mines.*

doned Noncoal Mines, available from the Western Governor's Association (Western Interstate Energy Board 1991; Interstate Mining Compact Commission 1992). This state-by-state scoping study reports physical hazards and acreage disturbed, plus for some states numbers of mineral locations. Unfortunately, data are "not comparable among states" because of differences in definitions among respondants. Nonetheless, the wealth of detail and the associated discussions make these reports useful and place the data on inactive mines in historic and geographic context.

Given these caveats, it is possible to draw a number of general conclusions from the preceding analysis. Perhaps most striking is the widespread nature of the issue. Mining has taken place in virtually every part of the United States, so there are past producers everywhere as well. Not all of these mines are problems, particularly since the mining industry began reclaiming recently closed mine sites. However, thousands of mines date from the turn of the century, when there were no environmental regulations. Some of these historic mines are creating environmental problems; many more present physical hazards; thousands are eyesores.

Public lands have been impacted by these unreclaimed mines. The MAS/MILS database lists more than 13,500 past producing mines within the administrative boundaries of NFS lands alone. Many of them currently, or have the potential to, degrade surface or ground water quality, and impact natural ecosystems. For example, arsenic, cadmium, copper, lead, mercury, zinc were mined as economic commodities at 7,765 of the locations. Because these elements often occur in polymetallic deposits, there are undoubtedly additional sites where they were coproduced and discarded. Many more sites are likely to have had these commodities present in uneconomic quantities. In addition, 1,500 of the past producers within NFS boundaries already have been identified as having significant acid mine drainage problems (USDA Forest Service 1992).

The legal and financial responsibility for protecting the public against physical hazards and for the reclamation of polluted sites belongs to the mine owner in the case of private lands, or the operator in the case of leases on acquired lands. But the owners of many historic mine sites are unknown or unlocatable. In these cases, responsibility for clean up is problematic. What is clear, however, is that the financial burden for a complete cleanup may be enormous. For that reason, prioritization of abandoned sites in need of reclamation is essential.

This report represents a first step toward the goal of understanding the abandoned mine problem by providing a national characterization of the distribution of sites. Other agencies are developing tools and methodology for hazard evaluation at abandoned mines (USBM 1994) or site specific risk assessment and prediction (Plumlee et al. 1993). Federal land managers and scientists are working closely with these and other agencies and with states and local governments to address the inactive and abandoned mine problem.

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U.S. Department of the Interior, Bureau of Mines. Cannot verify .... MAS/MILS designation utilized

Past producer .... A mineral location at which extraction has ceased and is not expected to recommence, given current technology and economics.[17]

Processing plant ..... A facility at which concentrate is processed to remove undesirable constituents or to concentrate desirable constituents. Includes smelters, refineries, acid plants.

[17] *The difference between a Past Producer and Temporary Shutdown is that at the former equipment has been sold and the plant dismantled. At a temporarily shutdown site equipment is present and minimal maintenance is ongoing.*

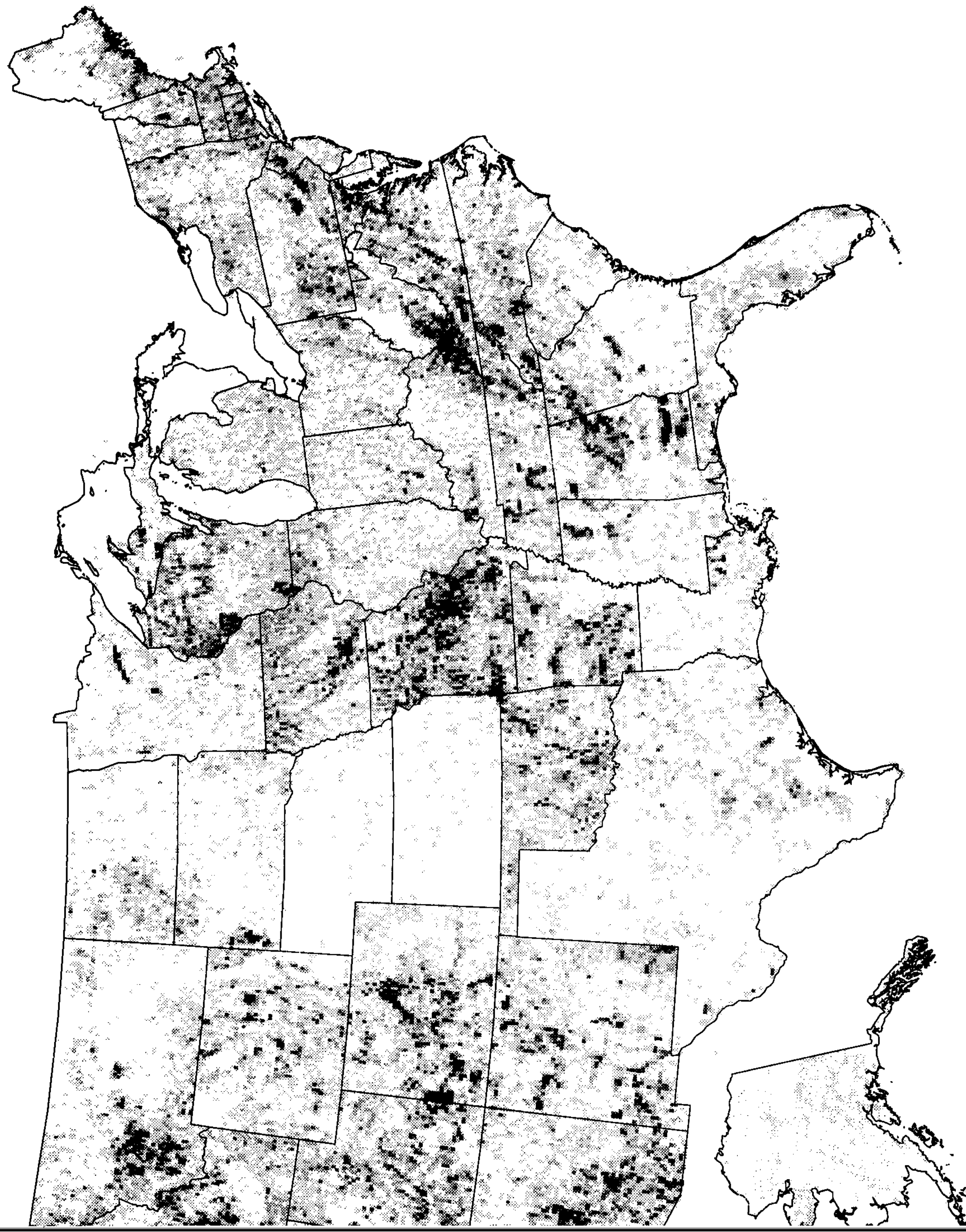
Raw prospect .... A mineralized site that has not been fully explored.

Status .... MAS/MILS designation for current activity at a mineral location.

Temporary shutdown .... A mineral operation that is not operating, but which may be reopened at some time in the future.

Type .... MAS/MILS designation for the method of extraction used at a mine.

Unknown .... See Cannot Verify.



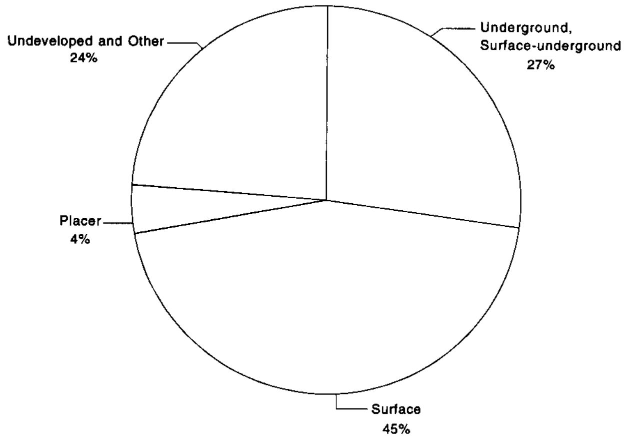


Figure 2.—Mineral locations by types (207,242). Some undeveloped deposits are listed in the MAS/MILS by expected mining method; so, results here are biased away from Undeveloped and Other.

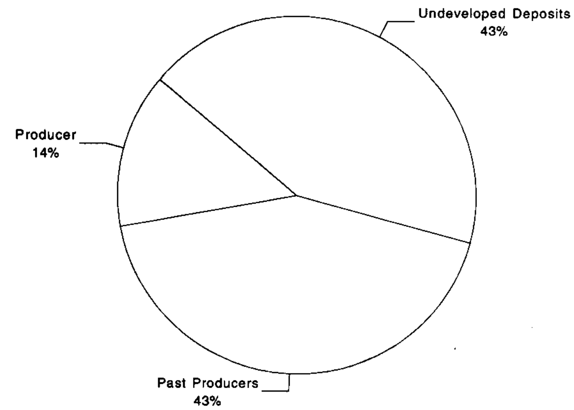


Figure 3.—Mineral locations by status (207,242).

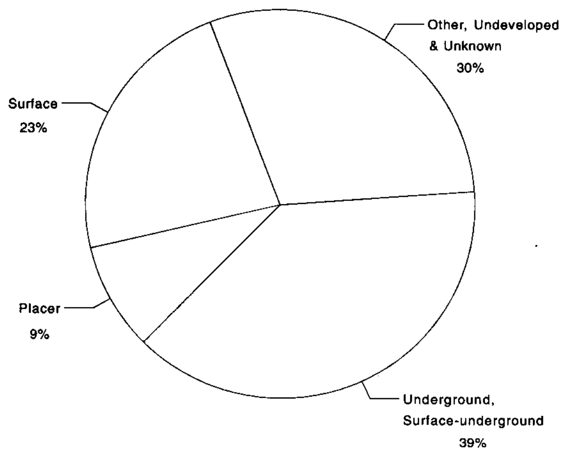


Figure 4.—Mineral locations by type on NFS (38,998).

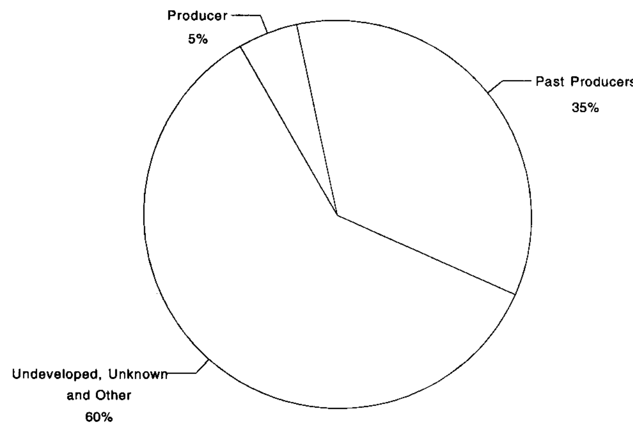


Figure 5.—Mineral locations by status on NFS (38,991).

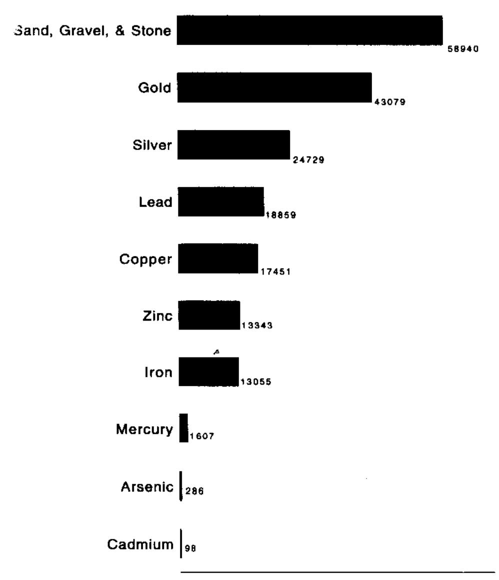


Figure 6.—Commodity occurrence. More than one commodity can occur at a location.

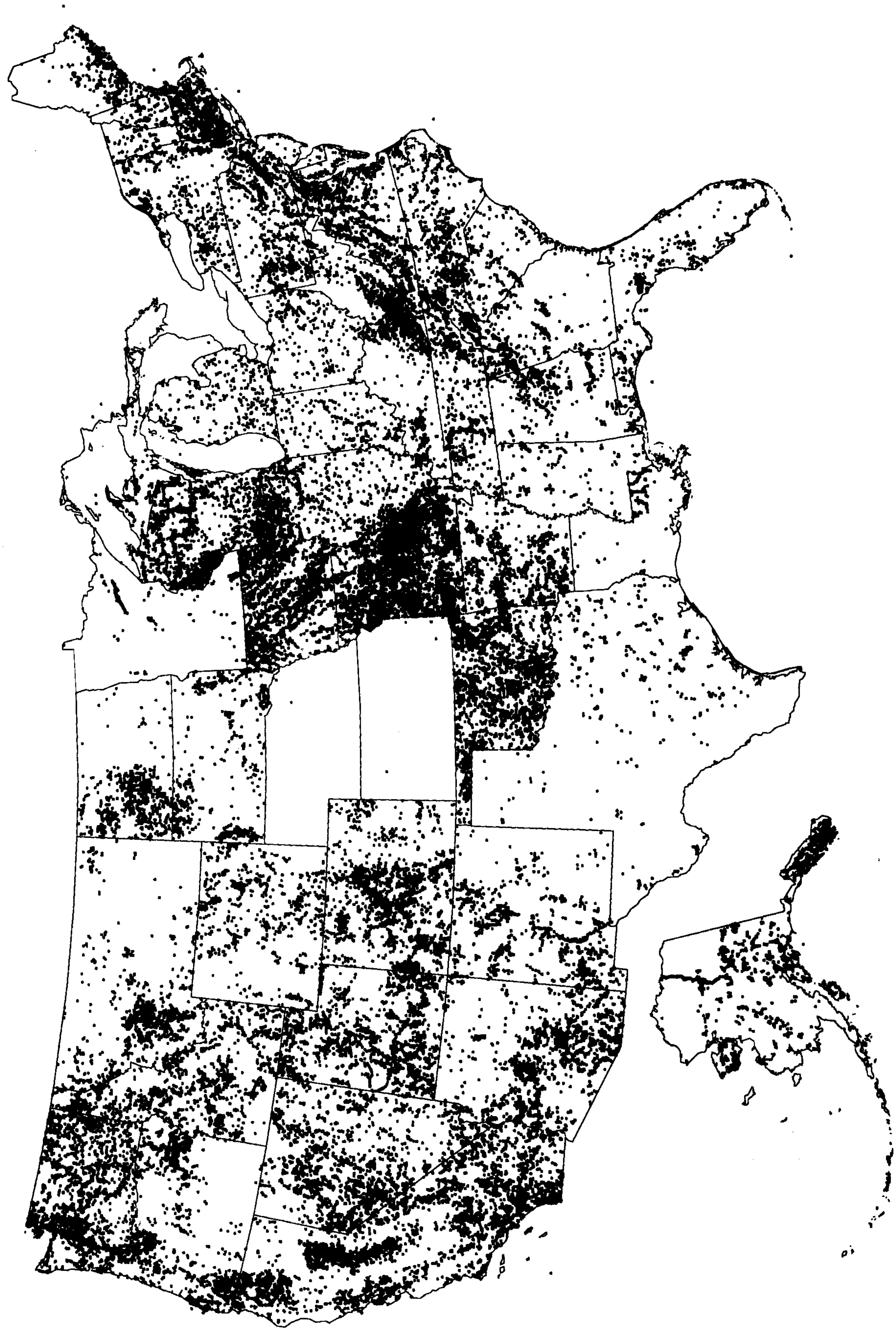


Figure 7.—Past producers - all.

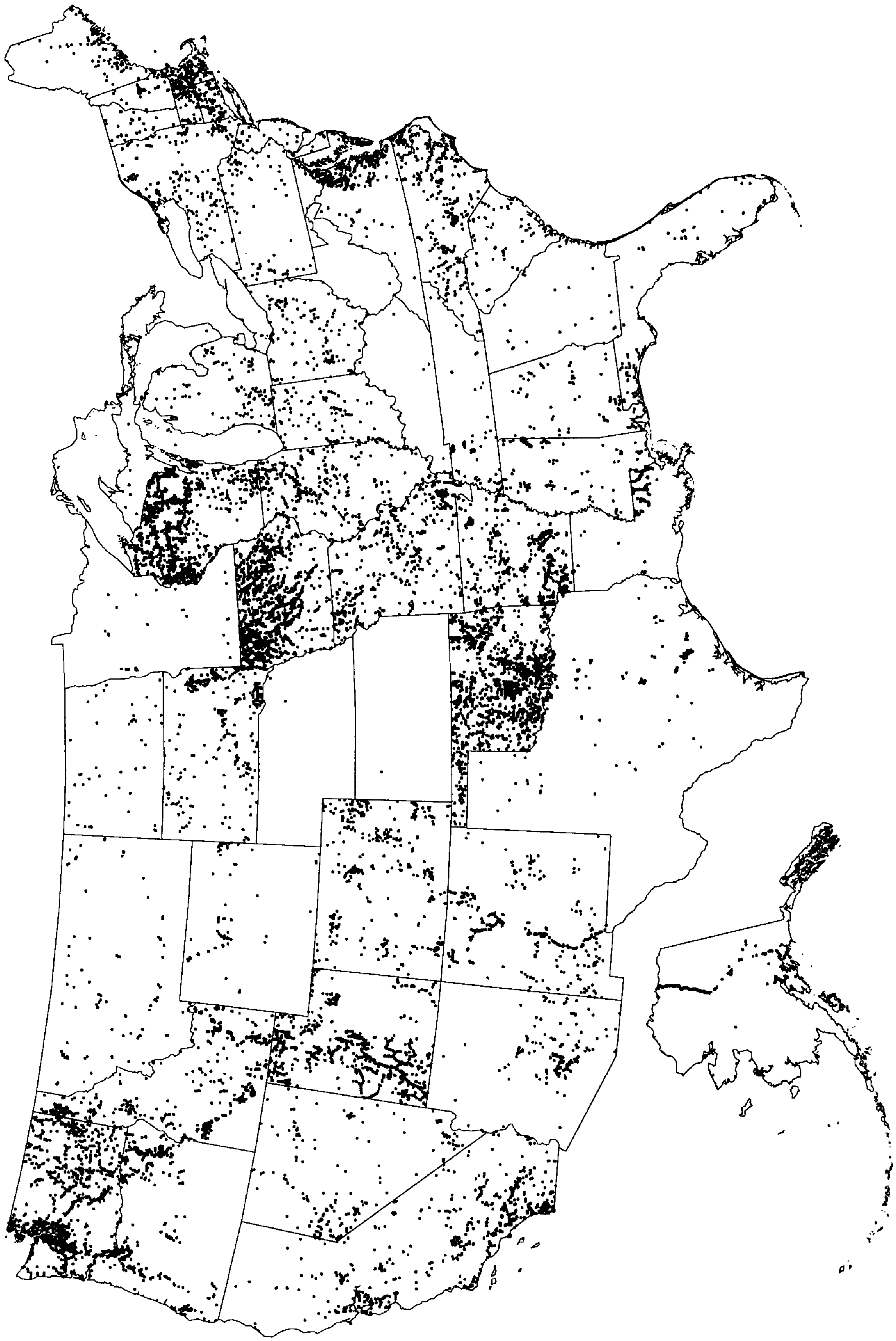
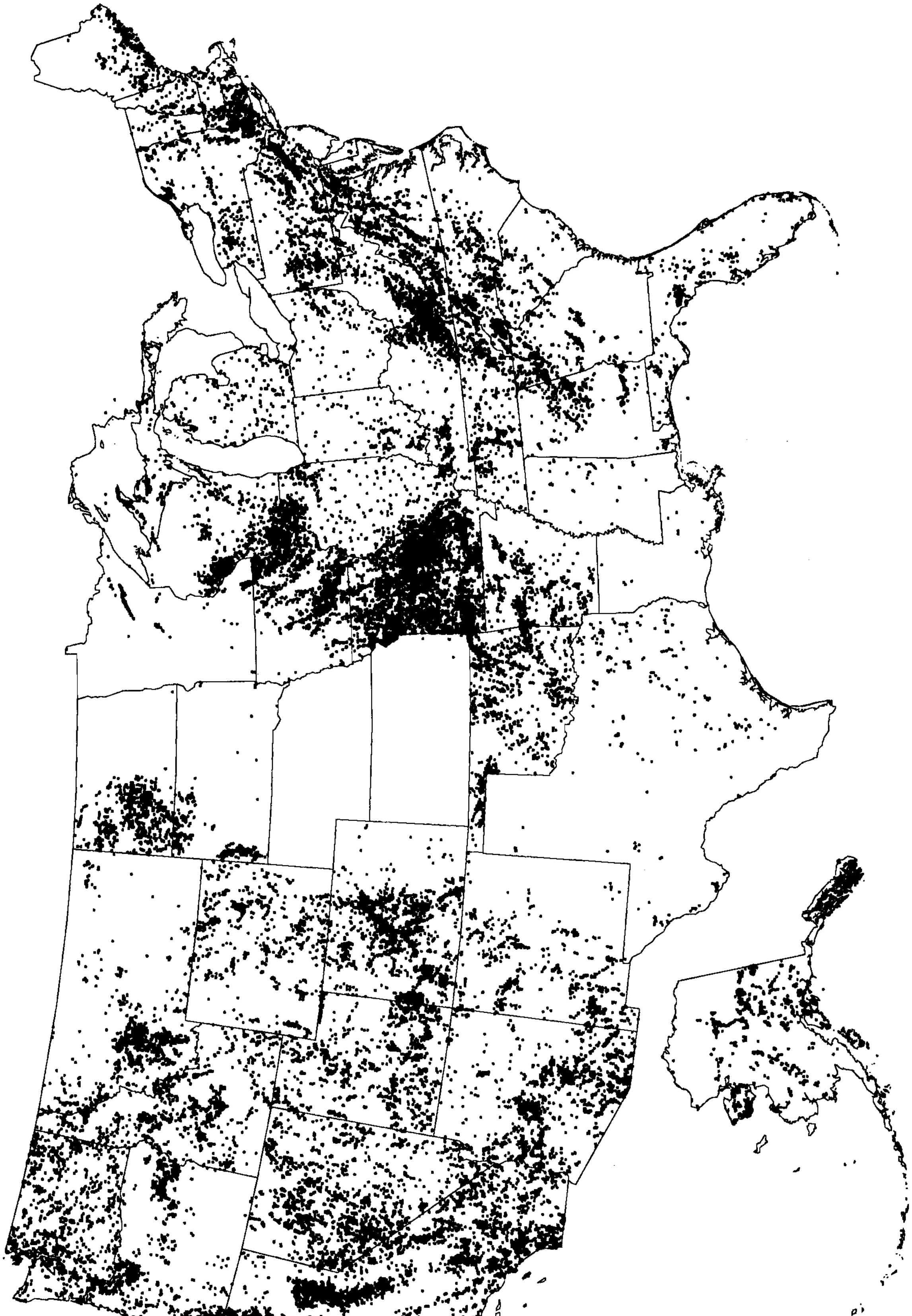


Figure 8.—Past producers - sand and gravel.



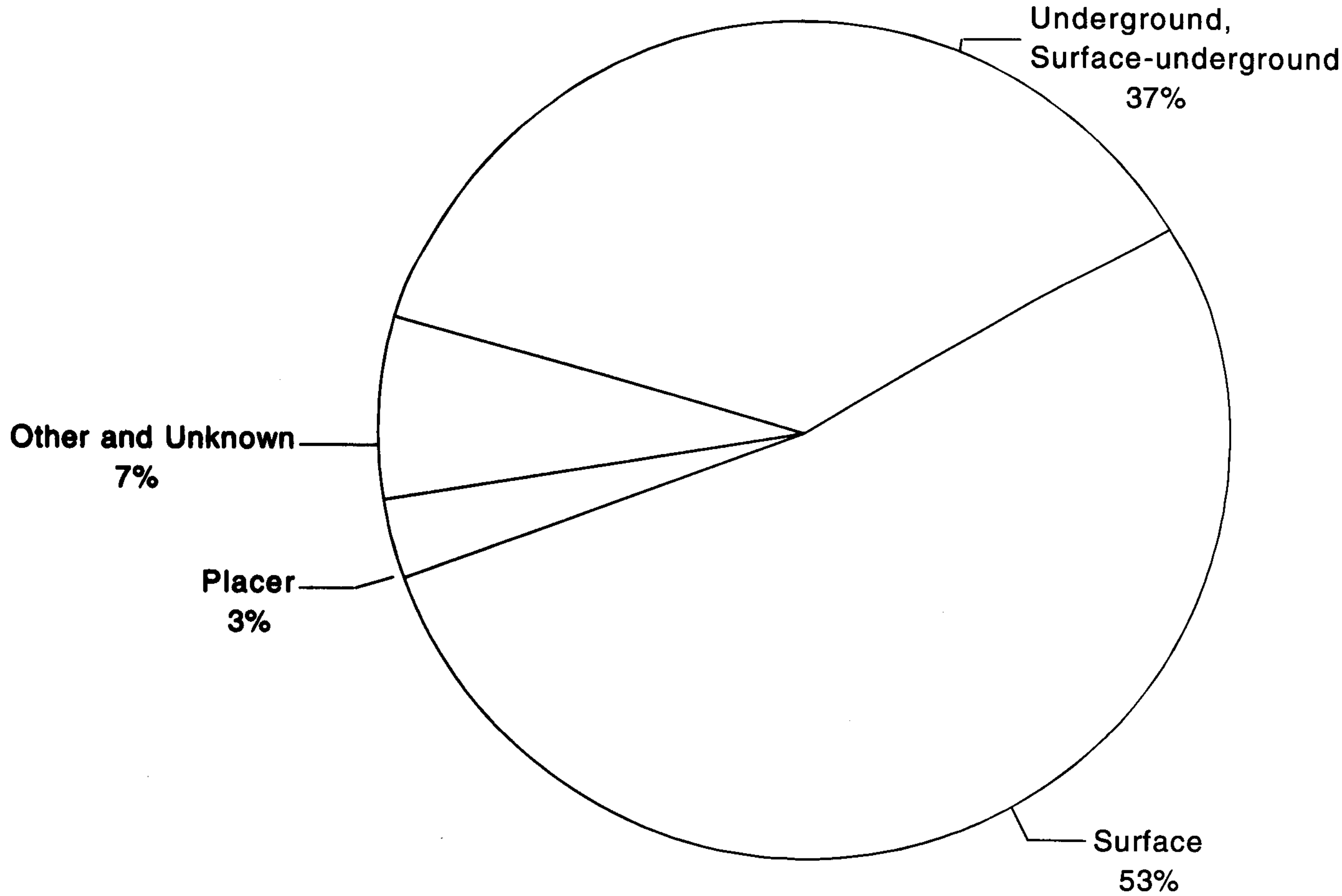
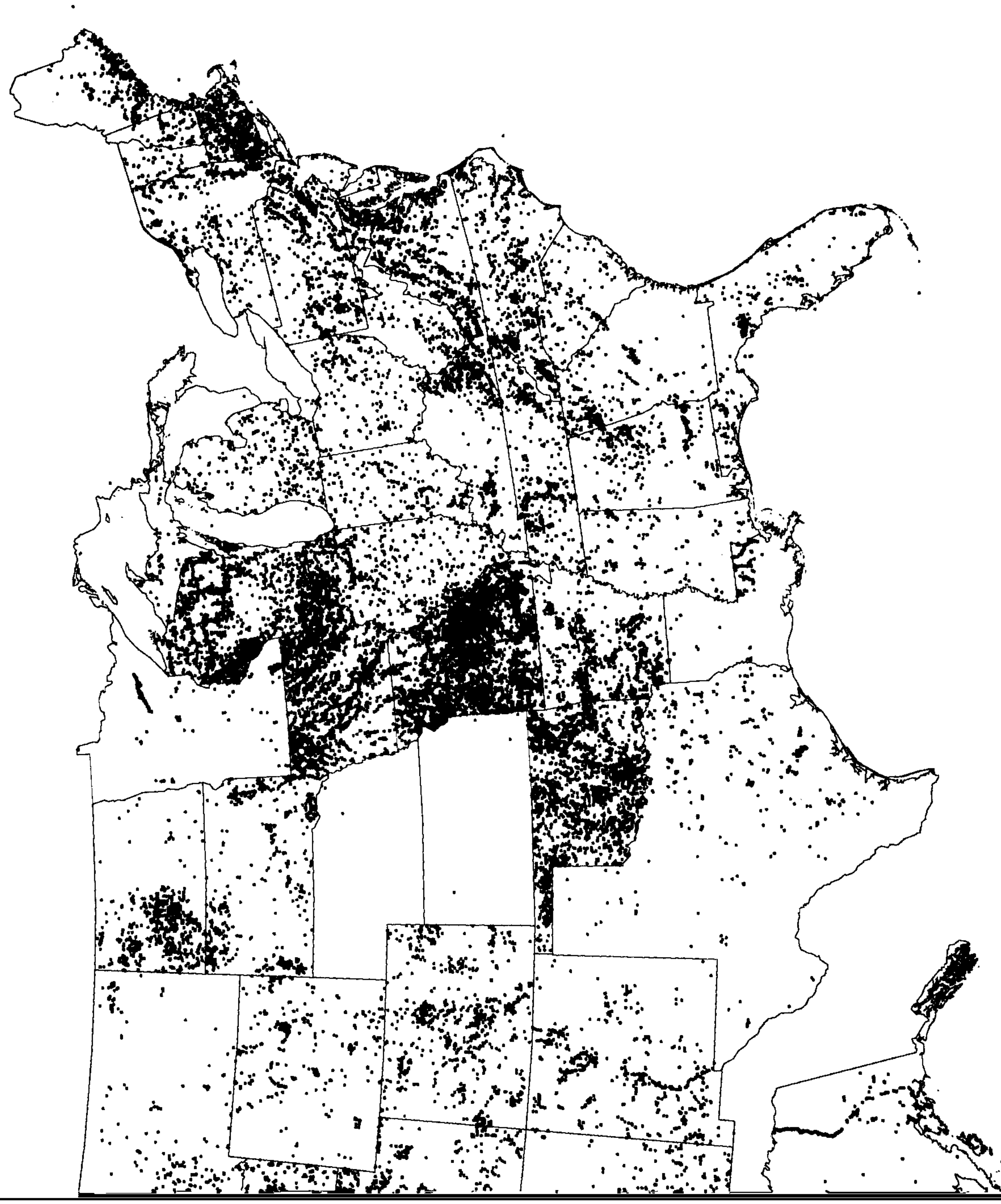
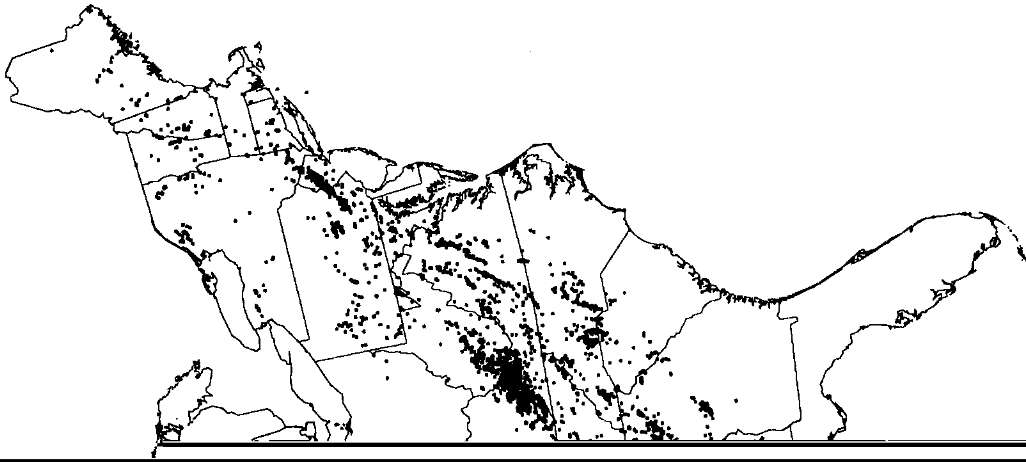


Figure 10.—Mineral locations by type - past producers (89,901 total).





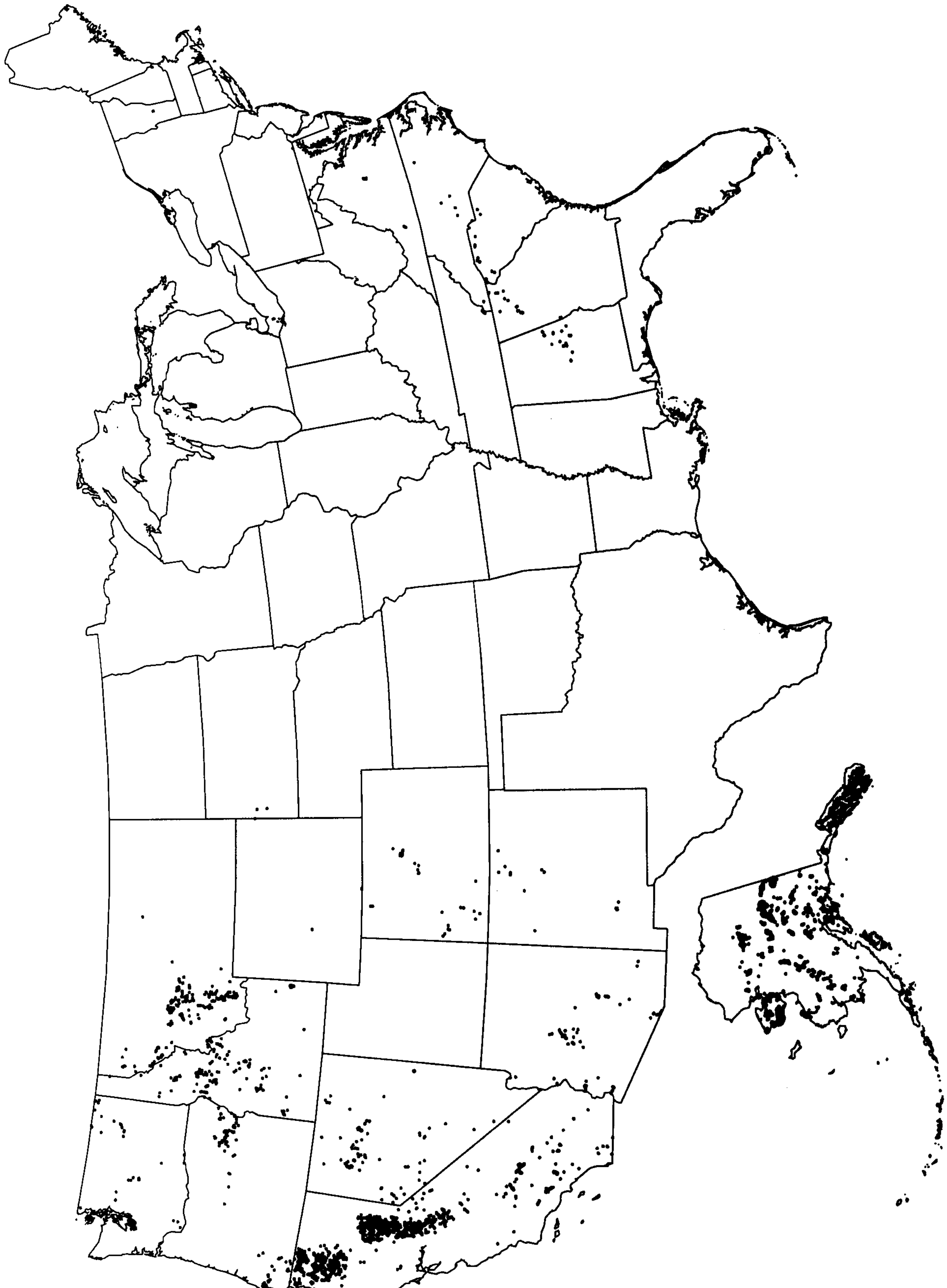
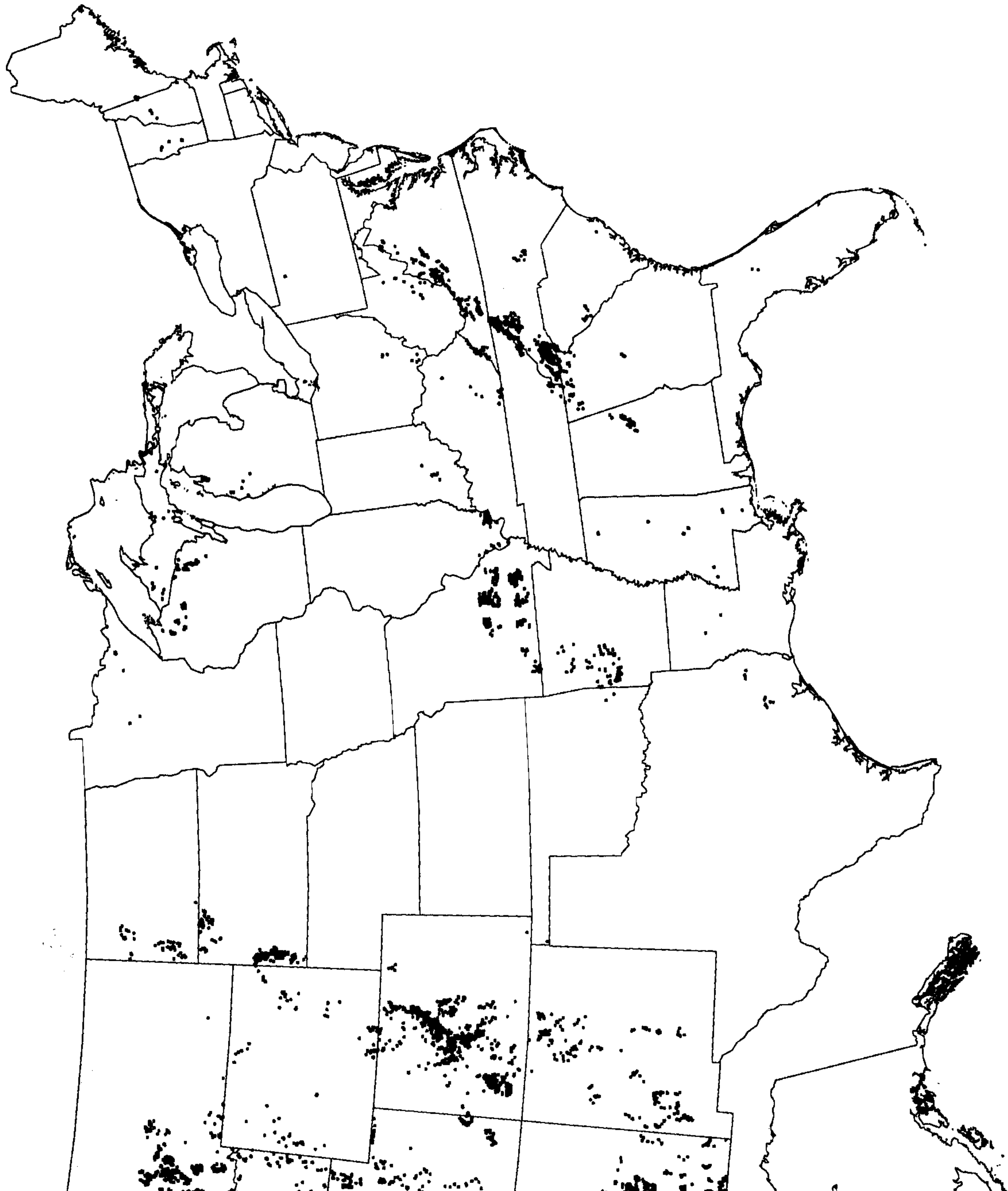


Figure 13.—Past producers - placer.



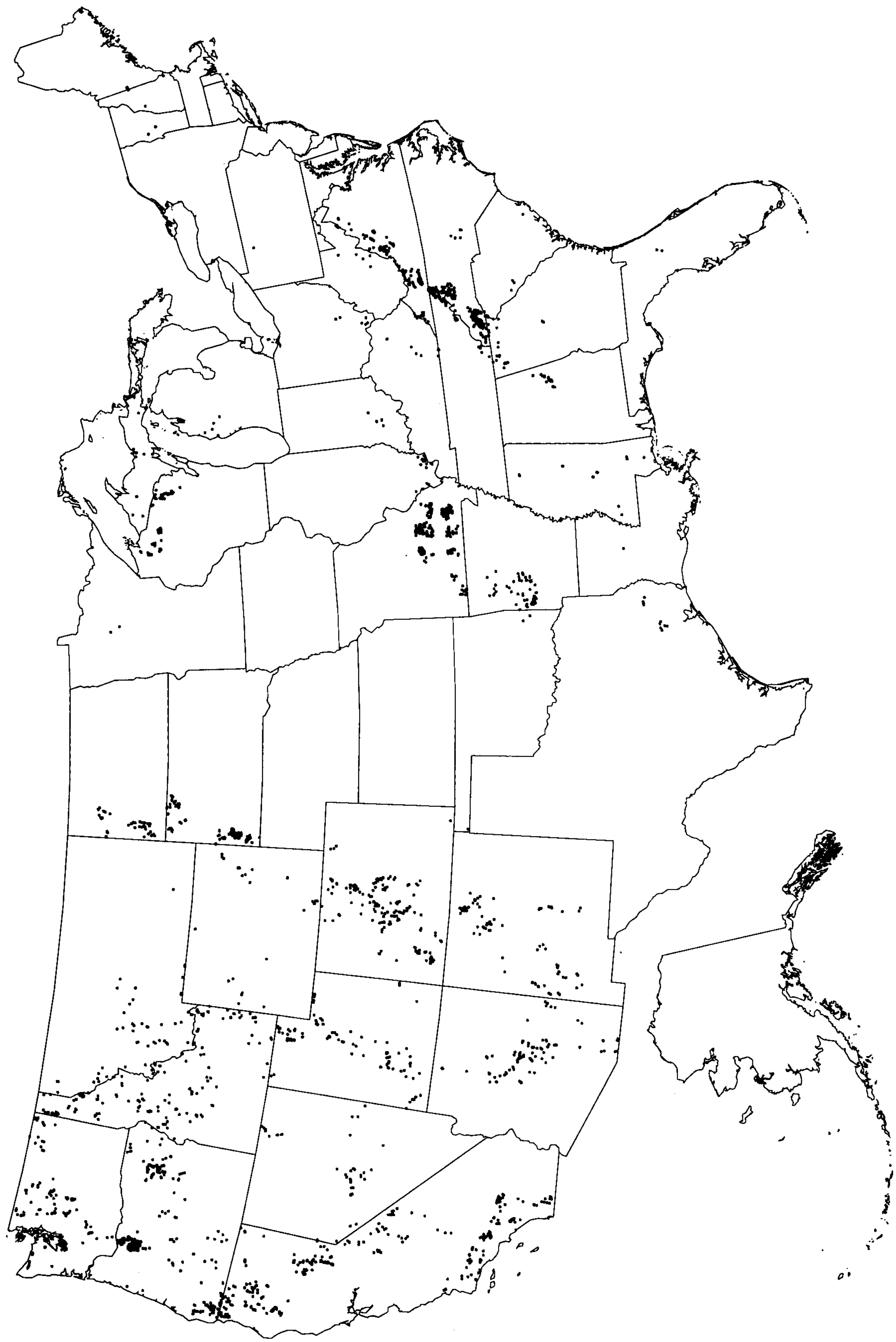


Figure 15.—Past producers - all NFS - surface.

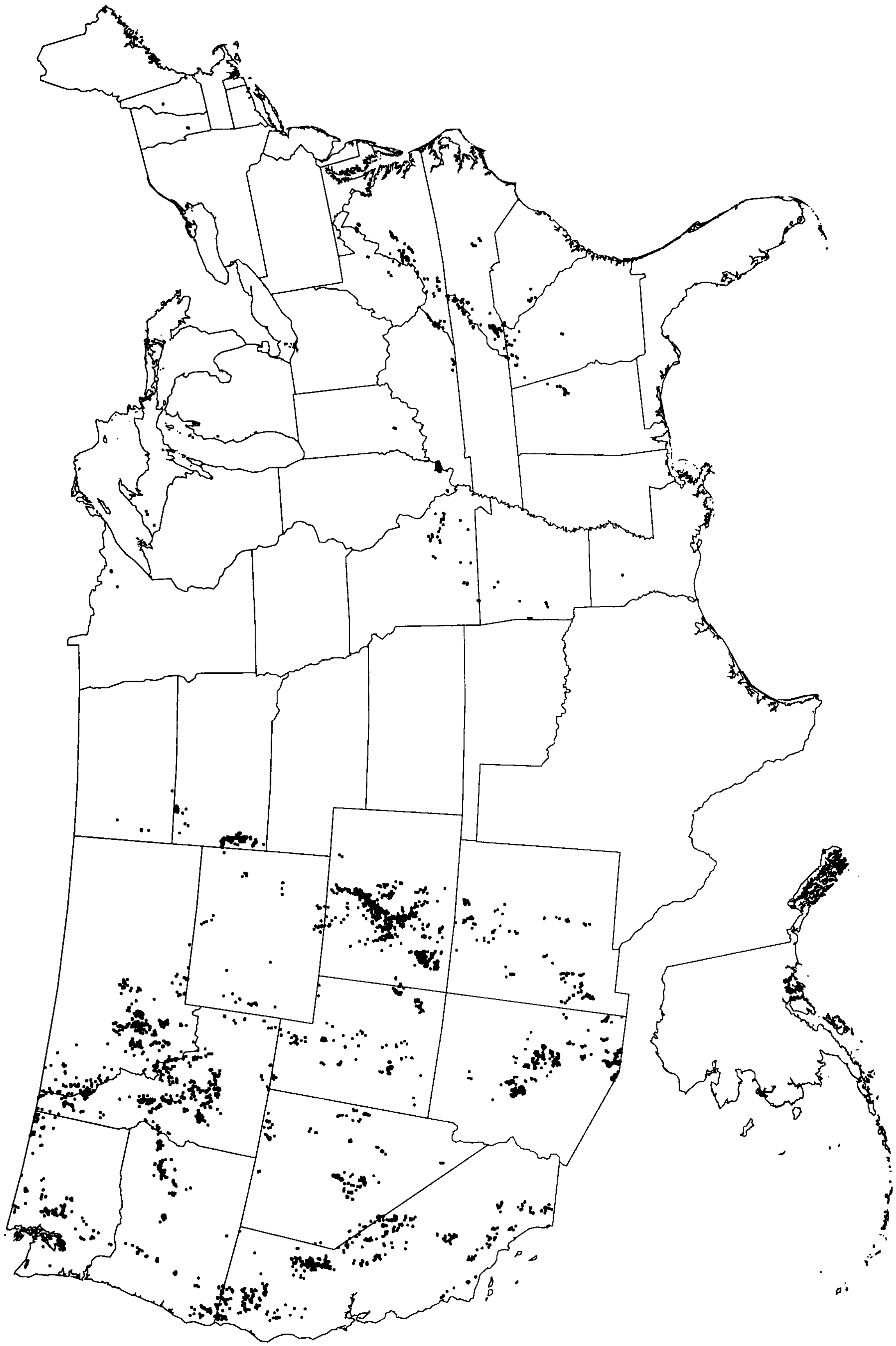
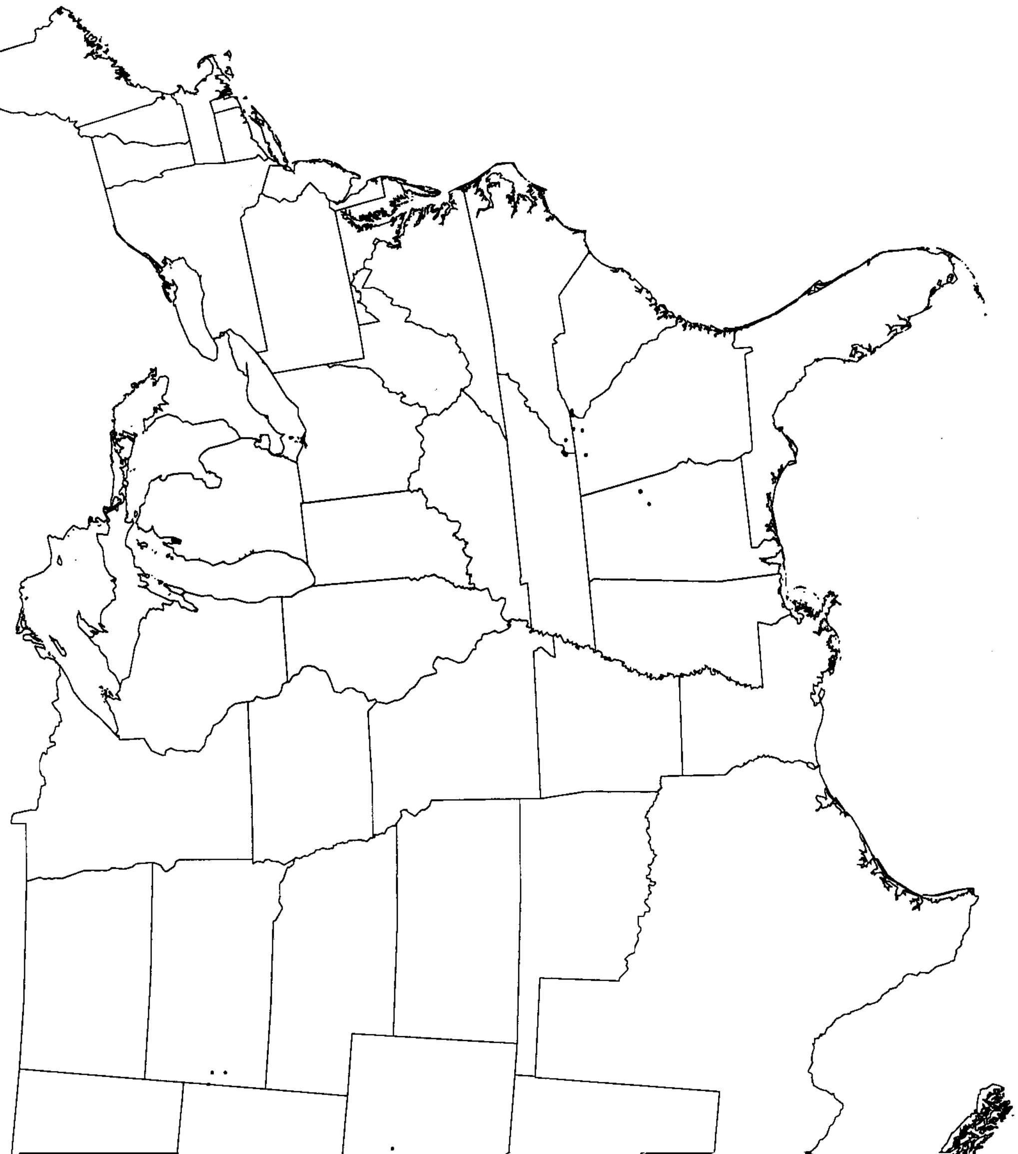


Figure 16.—Past producers - all NFS - underground and surface-underground.



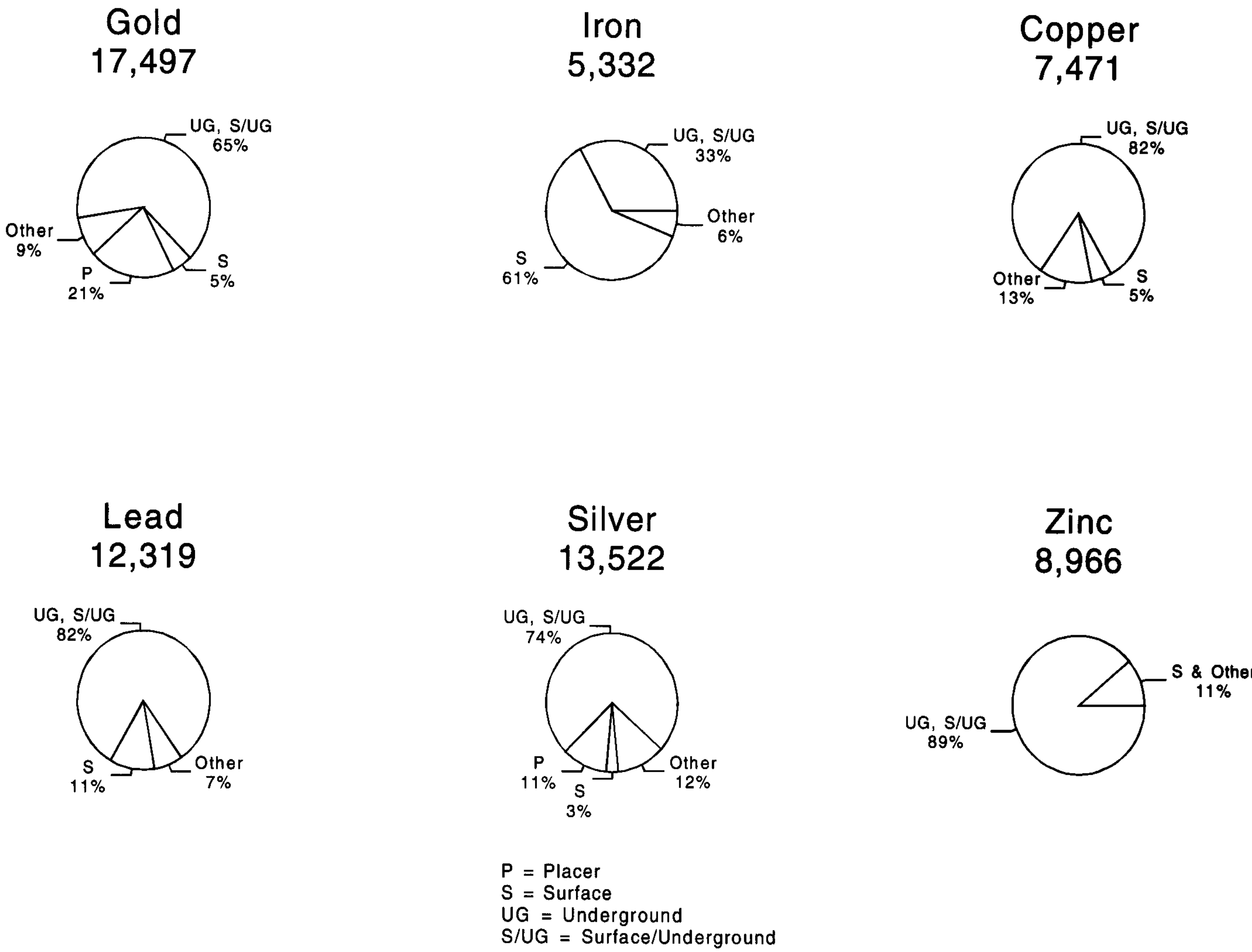
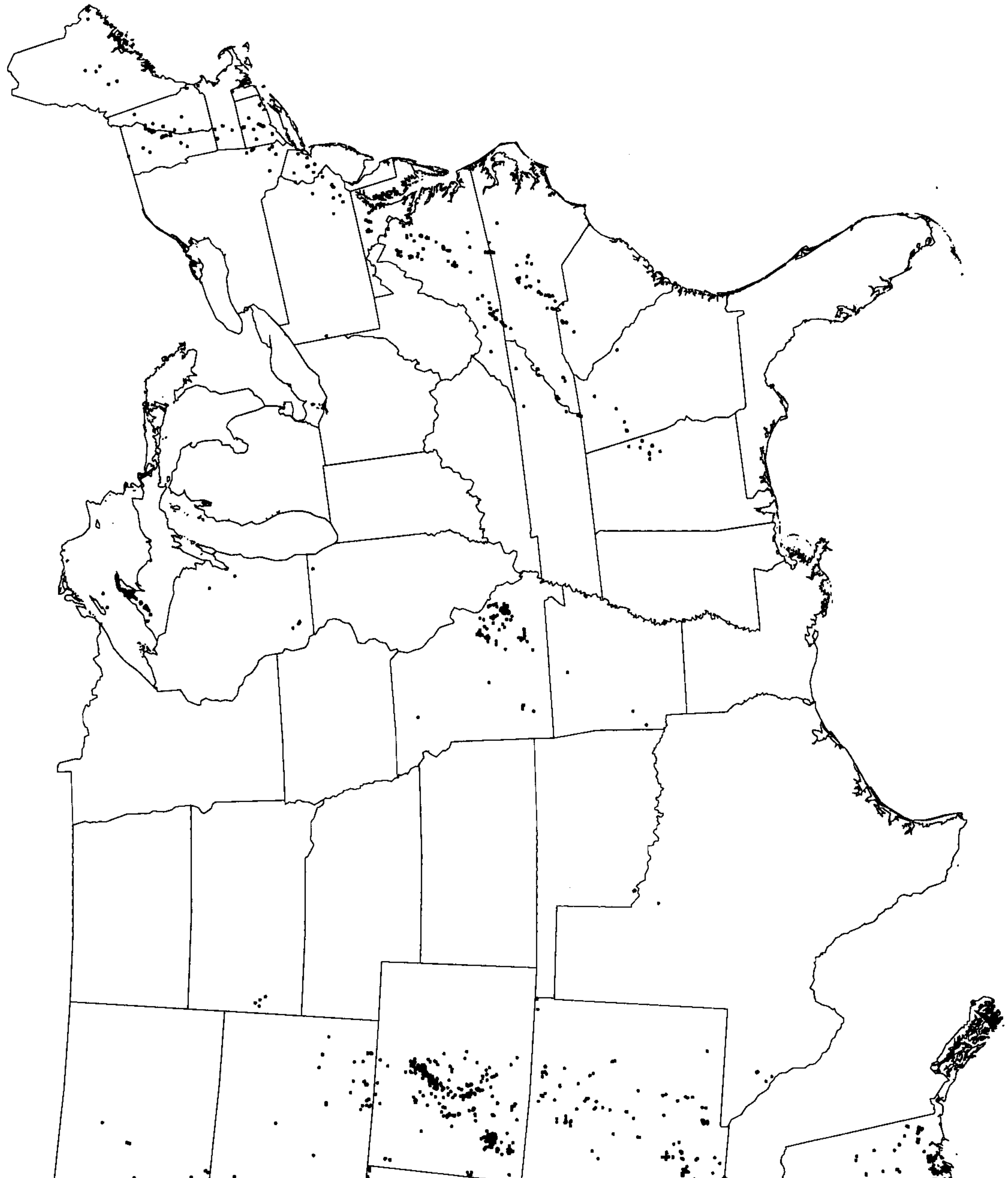


Figure 18.—Past producers - selected commodities.



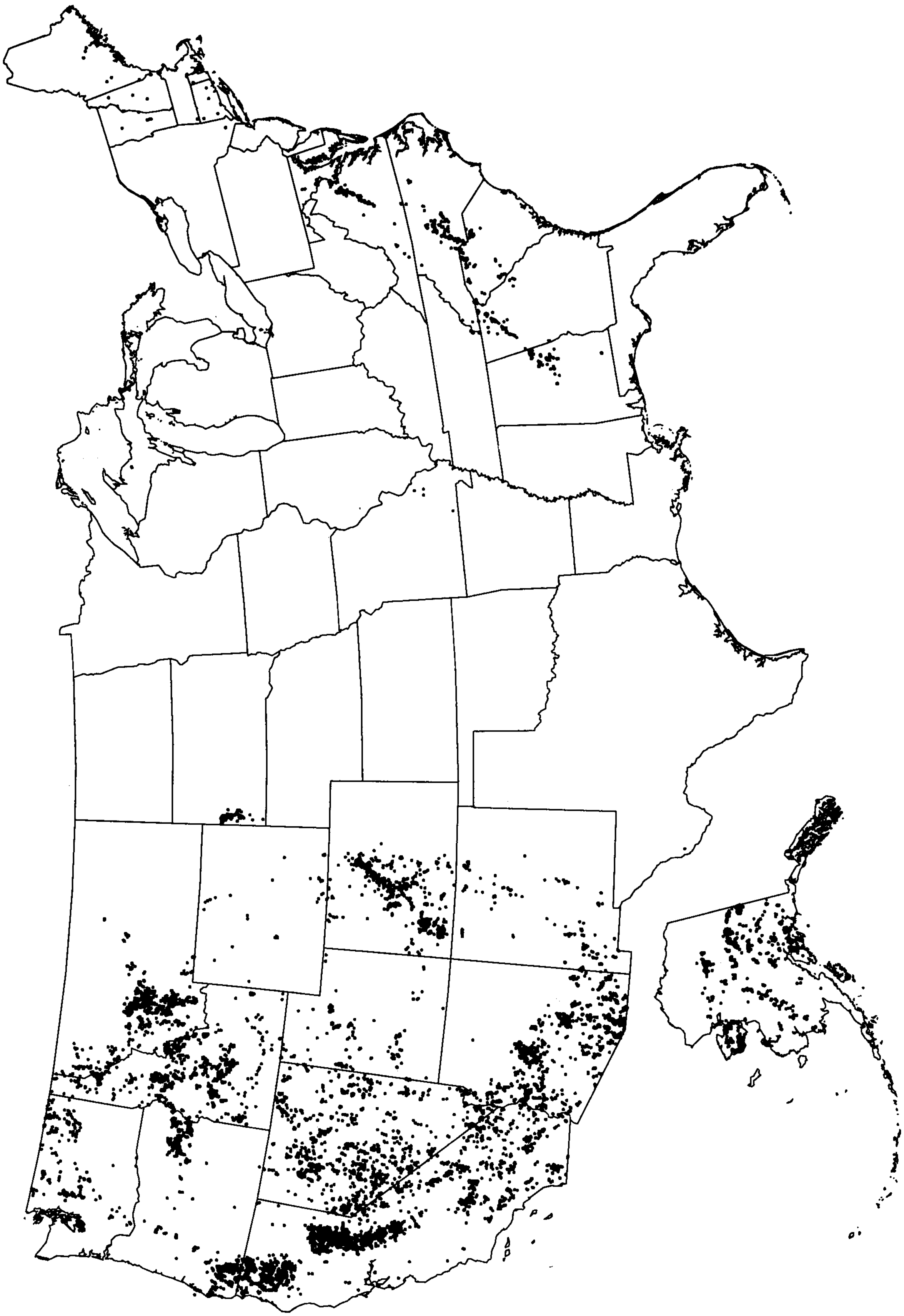


Figure 20.—Past producers - all gold.

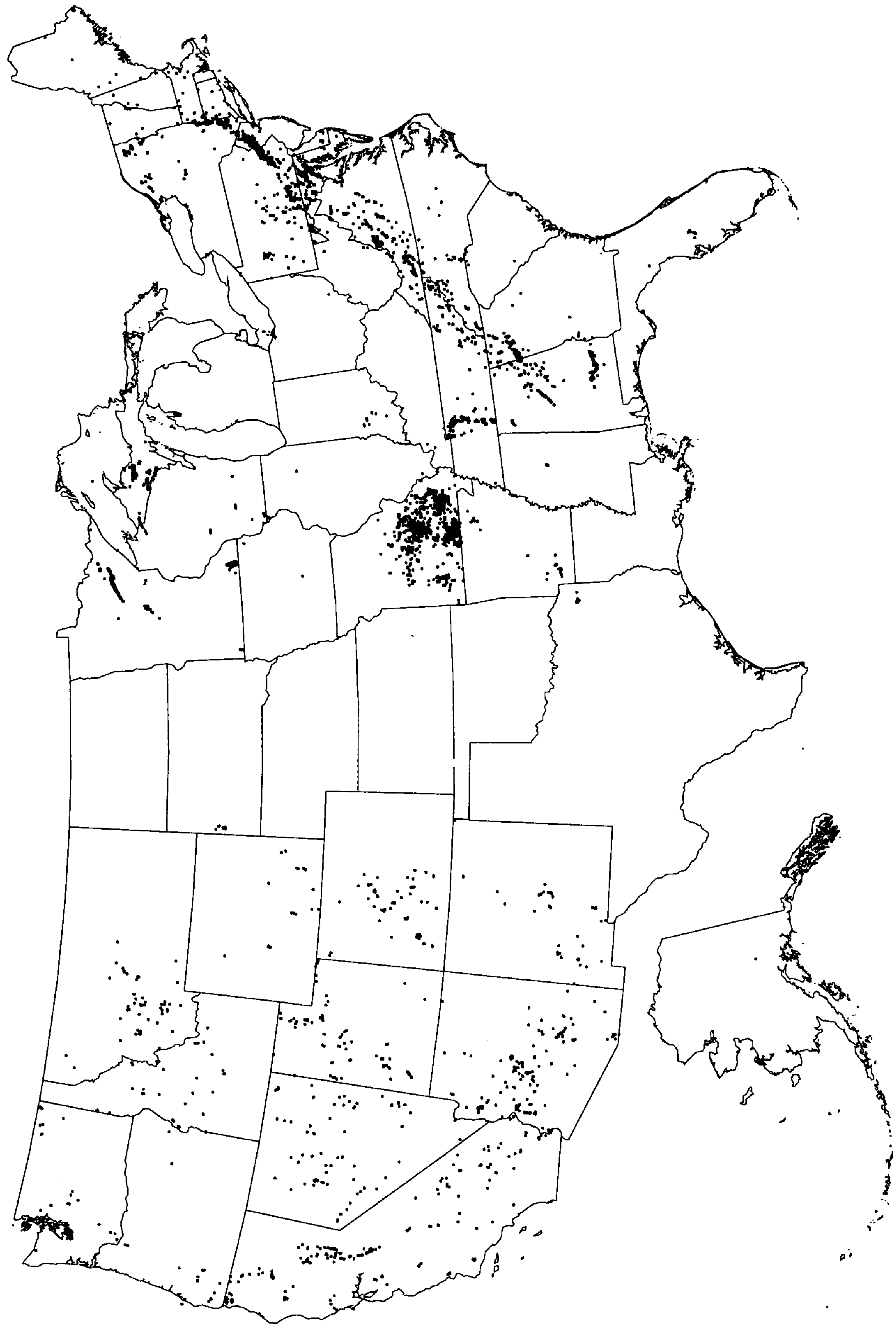
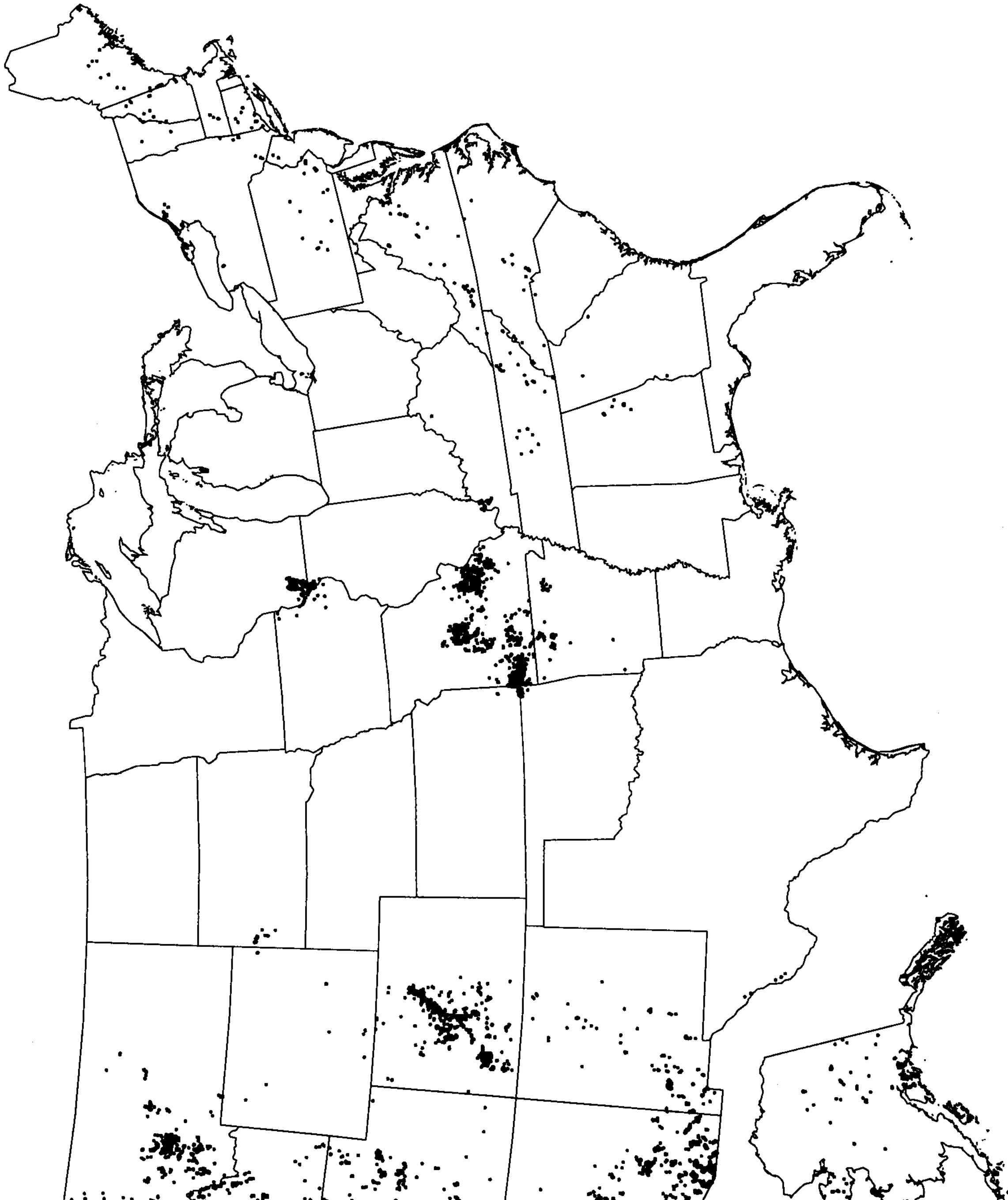
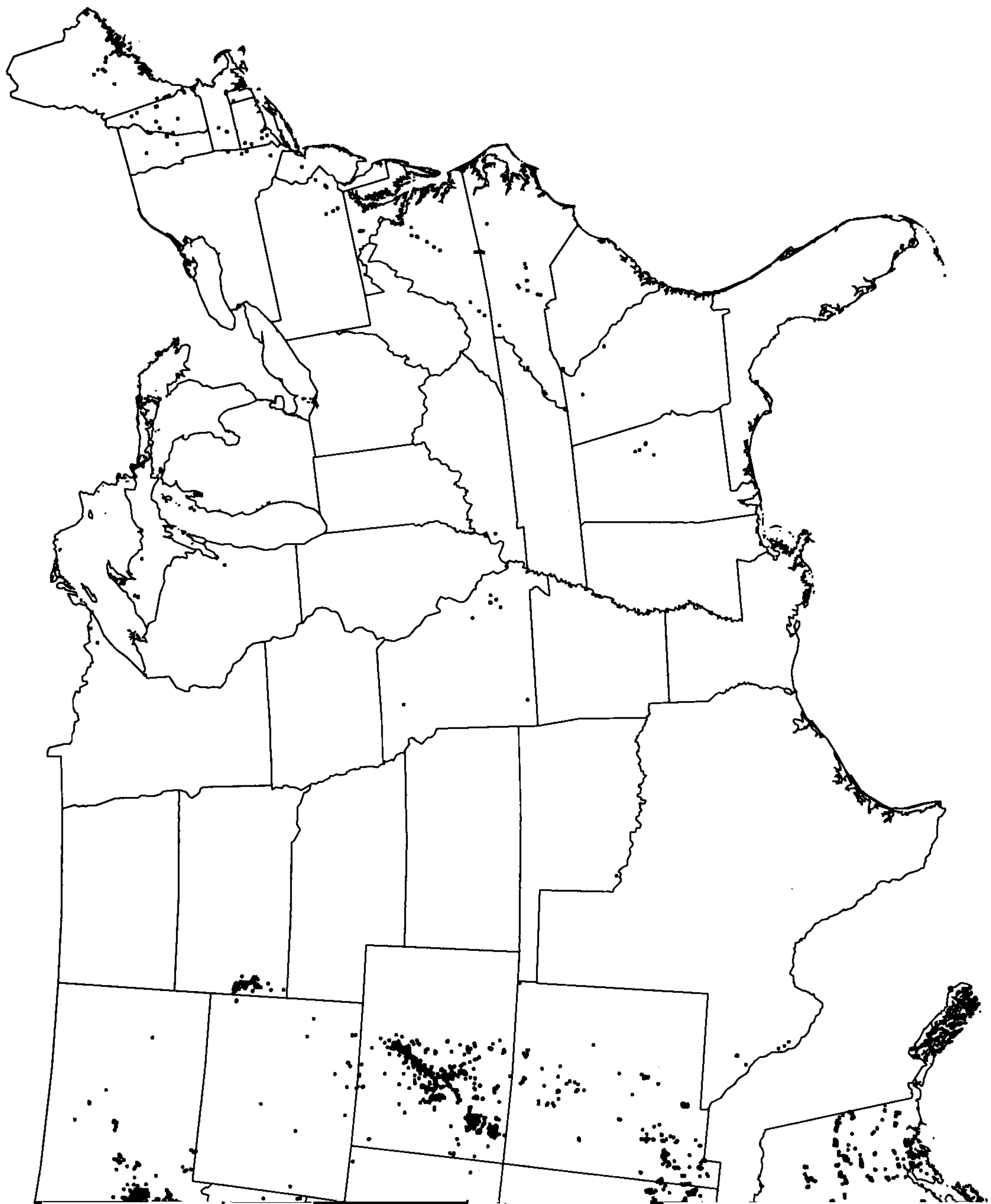
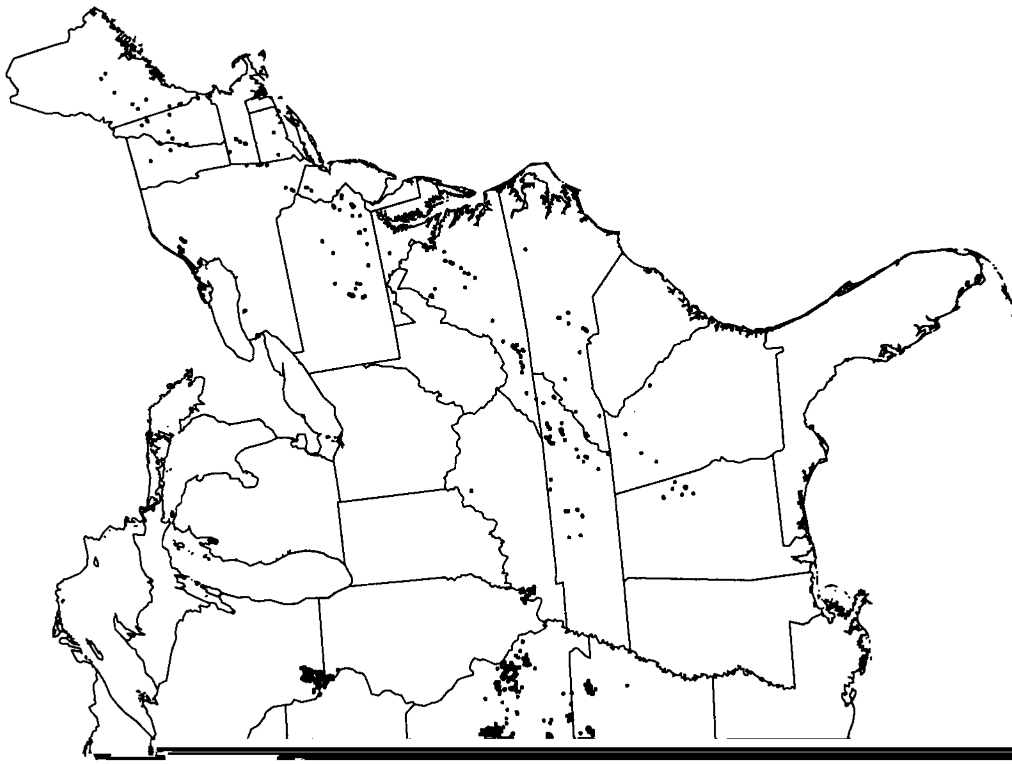


Figure 21.—Past producers - all iron.







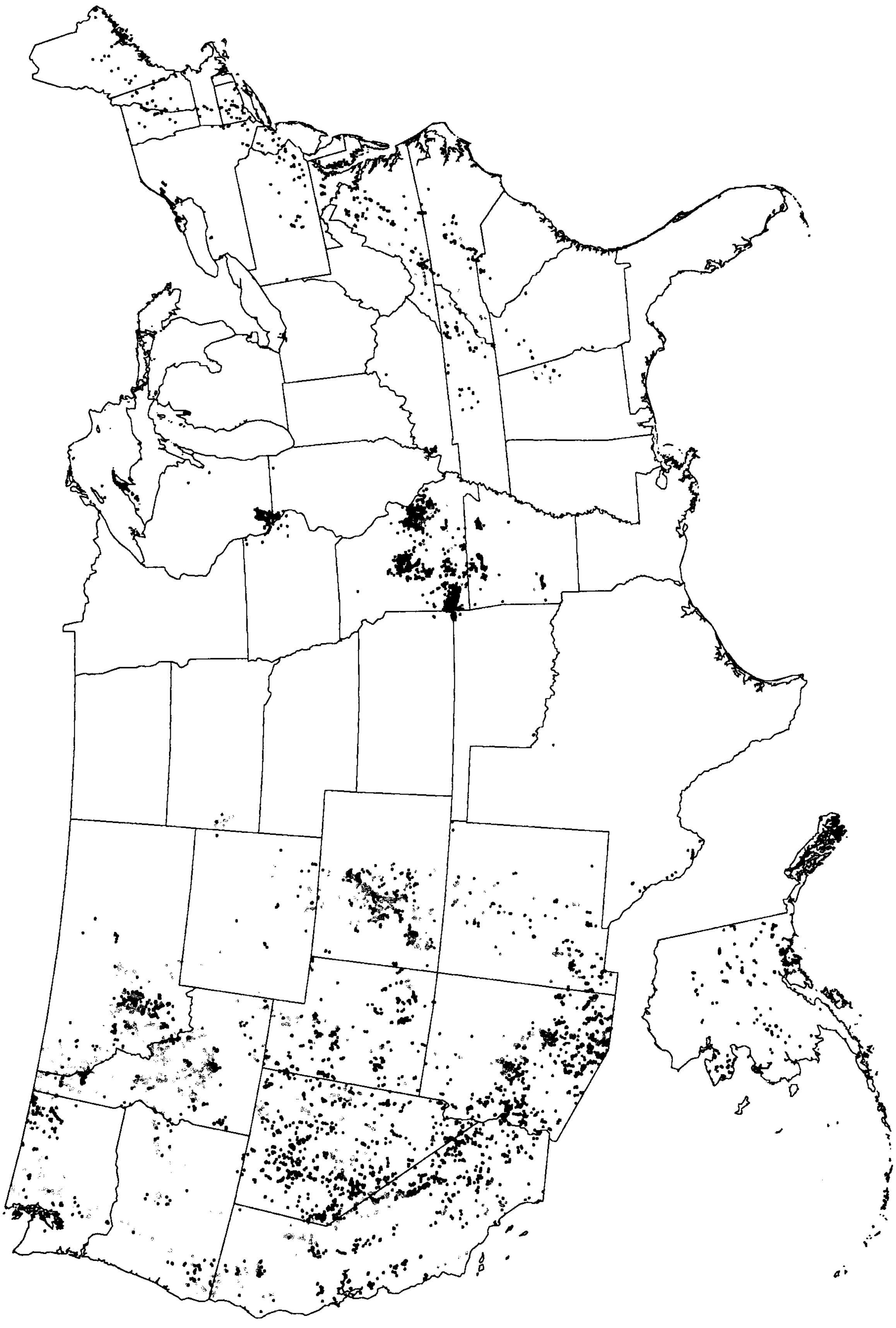


Figure 25.—Past producers - minerals of concern - all and NFS.

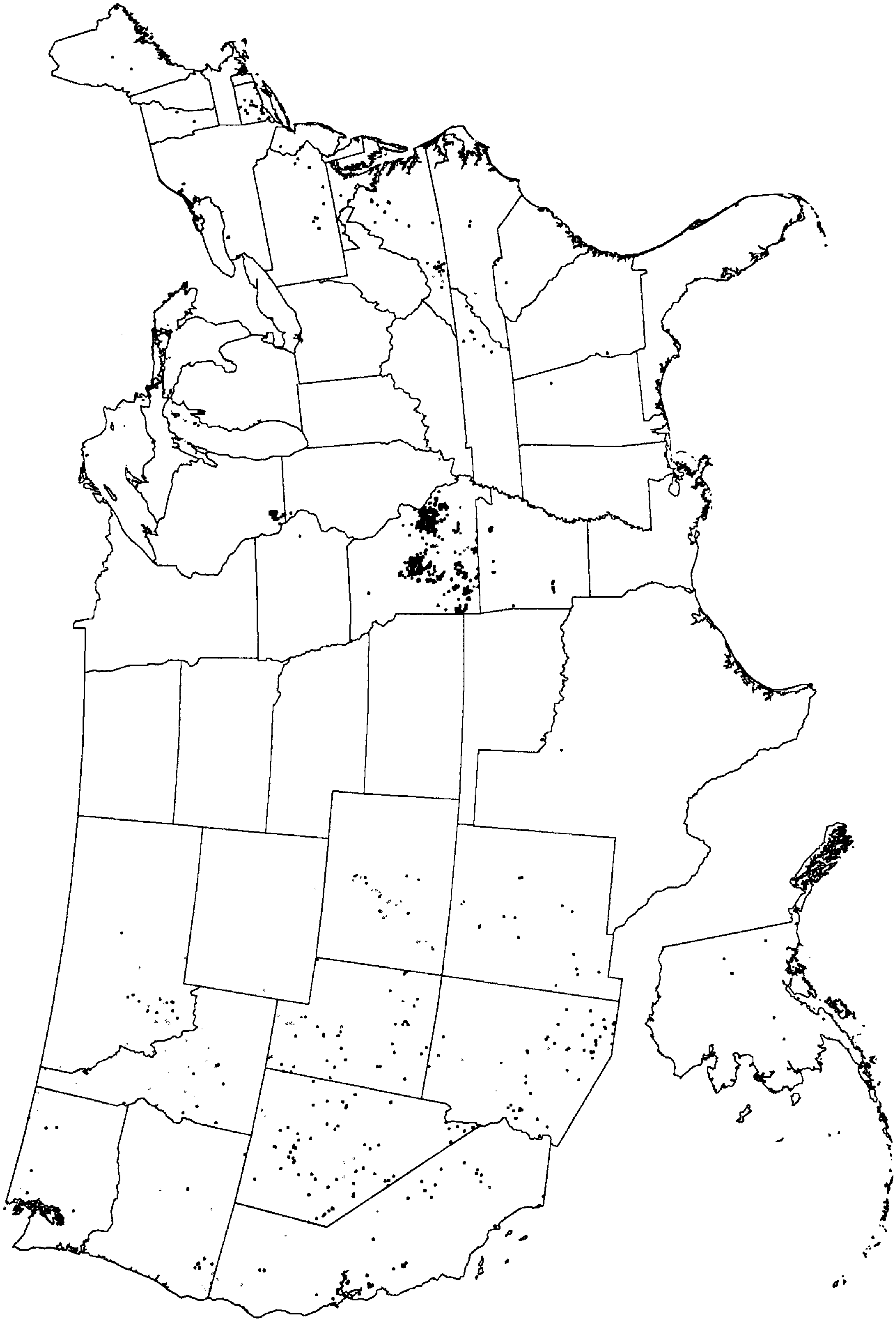


Figure 27.—Past producers - mineral of concern - all and NFS - surface.